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ABSTRACT

A review of cost-effectiveness analysis techniques was conducted in order to facilitate the selection of the most appropriate tool to aid any given instructional development effort. A survey was made of the cost-effectiveness techniques in current use, the differences among these techniques were examined in an analytical framework, and criteria for the selection of appropriate techniques were developed. The study yielded the conclusion that the variety of methods is due to choices available regarding 1) the level and process of analysis and 2) the analytical methods which can be employed. Selection of level and process was found to be generally beyond the control of the analyst, usually being determined by the nature of the study or the requirements of the requestor. However, a certain latitude in cost-effectiveness analytical method selection was felt available to the analyst. This latitude was determined by the characteristics of the analytical techniques available for use and these, in turn, were identified as the tabular display technique and the analytical model technique. (Author/LB)

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COST-EFFECTIVENESS ANALYSIS: THE SELECTION OF A DECISION-ASSISTING TOOL FOR INSTRUCTIONAL DEVELOPMENT

by

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University of Wisconsin-Madison

INSTRUCTIONAL SCIENCE ASSOCIATES

FORWARD

Cost-effectiveness analysis is becoming increasingly important as a decision-assisting tool to both government and industry. Cost-effectiveness analysis also has been a significant factor in the selection of alternative design in instructional development. The purpose of this monograph is to provide an overview of what is meant by cost-effectiveness analysis and to define the essential elements of the methodology for trade-off decisions by the instructional designer. The monograph includes a documentation and synthesis of the work of a variety of authorities, and presents their collective experiences. The treatment of this documentation and synthesis is to structure the information into a narrative and graphic description of the analytical process of cost effectiveness. Although the description includes considerable detailed information involving the documentation of steps in the various analytical techniques, the description is still less than would be required to perform all aspects of the steps by an instructional designer. The degree of detail maintained in this description, therefore, is considered to reflect the minimum information required for the performance of cost-effectiveness analysis by an instructional designer with moderate experience.

Robert H. Pearson

PREFACE

The purpose of this monograph is to identify the differences in cost-effectiveness analysis methods so that the most appropriate method can be selected as a decision-assisting tool in instructional design and development. It is intended that this approach will be of assistance to those instructional designers engaged in selecting alternative instructional strategies by providing the following:

- Insight into the field experience of others in instructional cost-effectiveness analysis.
- Recommendations for direct application of cost-effectiveness analysis principles to instructional design.
- Source information on instructional cost-effectiveness analysis, as well as reference to instructional designers with experience using cost-effectiveness analysis.

The principal organization of the monograph is to explore and identify what cost-effectiveness methods were being used; to identify and examine the differences among these methods in an analytical framework; and, to determine the criteria to be used in selecting the most appropriate instructional cost-effectiveness method for instructional design and development. The emphasis of the monograph is on the performance of instructional cost-effectiveness analysis as a service in support of the decision-making process by someone other than the final decision-maker. The descriptive detail provided in the study is such that an instructional designer with moderate experience could perform the indicated activities.

R.H.P.

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ABSTRACT

Much has been reported on the advantages of cost-effectiveness analysis as a decision-assisting tool for instructional development, but little has been reported on the actual performance of cost-effectiveness analysis itself. The study is structured to provide answers to the following questions:

- What cost-effectiveness analysis methods are available for use and how do they operate?
- What are the characteristics of the various cost-effectiveness analysis methods and in what way are the various methods different?
- What factors are to be considered in the selection of a cost-effectiveness analysis method for a specific situation?

What appears to be a large variety of cost-effectiveness analysis methods is due to a choice in the "level" of analysis; in the process of analysis; and, in the analytical methods employed within what might be called a standard step procedure. The choice of "level" and process of analysis is usually outside of the control of the cost-effectiveness analyst. This is because both "level" and process of analysis were found to be determined by the nature of the study or by the requirements of the requestor. Certain latitude in cost-effectiveness analytical method selection is available to the analyst and this latitude is determined by characteristics of the analytical techniques available for use. These techniques are the tabular display technique and the analytical model technique.

INTRODUCTION

Education currently consumes a vast amount of resources, and it appears almost certain that it will consume much more in the future. Since the systems analysis process makes possible the evaluation of alternative courses of action for the achievement of instructional goals and objectives, those involved in instructional design and development are enthusiastic over its potential as a viable base for decision-making. Cost-effectiveness analysis, one aspect of systems analysis, has been shown to aid in the better use of resources.

NEED FOR STUDY

It would seem that the current position on system/cost-effectiveness analysis is that many are enthused over its potential (McGivney, 1969, p. 31)--but who will perform the analysis and how the analysis will be done are more difficult considerations. It is possible that systems/cost-effectiveness personnel could be employed from the following areas:

- Government. Those individuals associated with the Department of Defense and their prime contractors who hope to transfer their professional and scientific capabilities from defense to education-oriented activities (Lieberman, 1968, p. 24).
- Business. Independent consultants with no vested interest in hardware or a product (Herbert, 1967, p. 45).
- Education. Educators and administrators responsible for planning (Heinich, 1969, p. 330) and instructional designers (Allen, 1967, p. 377).

Attaining a process by which cost-effectiveness analysis may be applied to instructional design and development, however, is a more formidable task. One difficulty is that although much has been reported on the advantages of instructional cost-effectiveness, only a limited number of "how to do cost-effectiveness" studies have been published (Fisher, 1967, p. 69). Another problem is that the usefulness of cost-effectiveness analysis is not fully understood by many instructional designers. This lack

of understanding is due to the apparent coldness of the tool as a measure of decision-making (Banghart, 1969, p. 206) as well as other reasons. The following observations document these other reasons:

- At the current state of development of analytical methods, cost-effectiveness analysis is an art rather than a science. Long range planning decisions are too complex for the current state of analytical art to handle.

- Cost-effectiveness analysis is difficult to understand because of the confusion of semantics and meaning (Fisher, 1967, pp. 66, 68 & 70).

- The reliability of cost-effectiveness analysis is closely correlated with the experience of the individual analyst. Lack of consistency between analytical techniques results in questioning the merits of cost-effectiveness as an aid to decision-making (Kazanowski, 1968, p. 113).

- Cost-effectiveness analysis takes up too much time to be useful (Fisher, 1967, p. 67) and is not worth the bother of using it. Cost-effectiveness analysis itself should be the subject of a cost-effectiveness study (Hartley, 1968, pp. 235-236).

There are a variety of cost-effectiveness analysis methods in use today which differ in their respective advantages and limitations (Seiler, 1969, pp. 1-2). As new approaches develop, these methods constantly undergo subtle, but significant, changes (Kazanowski, 1968, p. 163). Although most of these new approaches are primarily mathematical in nature, a few are directed toward a better treatment of problems that cannot be handled by purely quantitative methods (Quade, 1968, p. 242).

With the apparent lack of understanding, limitations, criticism, and wide differences of approaches in cost-effectiveness analysis, the following question seems appropriate. How can this analytical tool, which was designed as a decision-assisting aid in the selection of technical systems, be used in efforts to attain the less tangible objective of increasing student achievement (Freedman, 1969, p. 31)?

PURPOSE OF STUDY

The principal purposes and organization of this monograph are to: (1) explore and identify what cost-effectiveness methods are being used, (2) identify and examine the differences of these methods in an analytical framework which accounts for the major variables identified, and (3) determine the criteria to be used in selecting the most appropriate cost-effectiveness analysis method for instructional design and development. As noted, there are a variety of cost-effectiveness analysis methods and these differ in approach and precision.

It is suggested that differences in cost-effectiveness analysis methods can be identified, so that the most appropriate analytical method may be selected as a decision-assisting tool in instructional design and development. The monograph will answer the following questions:

- What cost-effectiveness analysis methods are available for use and how do they operate?
- What are the characteristics of the various cost-effectiveness analysis methods and in what way are the various methods different?
- What factors are to be considered in the selection of a cost-effectiveness analysis method for a specific situation?

LIMITATIONS

Due to the complexity of the area of systems/cost analysis, the study will be limited to the process of cost-effectiveness analysis itself. In addition, the emphasis will be on the performance of the cost-effectiveness analysis by someone other than the final decision-maker, as an instructional design and development service in support of instructional management.

COST-EFFECTIVENESS ANALYSIS METHODS

The purpose of instructional cost-effectiveness analysis is to provide the decision-maker with data on the cost (resource consumption) and the probable effectiveness (quality of results to be achieved) for each of several alternatives, among which he must choose one course of action. Cost-effectiveness analysis involves clarifying the relationships between these two factors (cost and effectiveness) so that the decision-maker can strike the best balance between them. Cost-effectiveness analysis is not a substitute for judgment, experience, and common sense. It is a method for the systematic examination of all the subjective and objective data available (Heymont, 1965, p. 1).

PERFORMANCE

The current trend in the performance of cost-effectiveness is the application of the method by all levels of decision-making, in a variety of functions, and for both short-range and long-range planning (Heuston & Ogawa, 1966, p. 243). The analysis itself may be performed by the decision-maker, by a specialist within the decision-maker's organization, or the responsibility for cost-effectiveness analysis may be delegated to a specialized service organization (McGivney, 1969, p. 31). The latter approaches require close cooperation and coordination between the cost-effectiveness analyst primarily responsible for the study, the decision-maker requesting the study, and each of the other individuals providing informational inputs (Fields, 1966, p. 517).

At best, cost-effectiveness analysis functions as a tool used in providing the decision-maker with an analytical foundation for making sound objective choices among the various ways a problem might be solved or an objective met (Jarrett, 1967, pp. 7 & 9).

DEFINITION

The definition of cost-effectiveness analysis varies, for the methodology is not precise enough to mean the same thing to all practitioners in the field (Seiler, 1969, p. 1). Broadly defined, it is an analytic study designed to assist a decision-maker in identifying a preferred choice among possible alternates

(Quade, 1969, p. 1). The choice of alternates involves two approaches: (1) fixed-cost and flexible effectiveness approach; and, (2) fixed-effectiveness and flexible cost approach (Kazanowski, 1968, pp. 126-127).

Attention should also be given as to what is not cost-effectiveness analysis. Kazanowski calls this the "maximum-effectiveness-at-minimum-cost fallacy" and defines this misconception as follows:

> Many references can be found in which the statement is made directly or indirectly that cost-effectiveness is a technique by which one determines that alternative which yields the maximum effectiveness at a minimum cost. Or, in other words, that alternative is sought by which the cost is minimized. In reality the attempt to find such an alternative is doomed to failure at the onset, because such an alternative does not exist. Hitch and McKean state: "Actually, of course, it is impossible to choose that policy which simultaneously maximizes gain and minimizes cost, because there is no such policy" (Kazanowski, 1968, p. 160).

EFFECTIVENESS/BENEFIT DIFFEPENCES

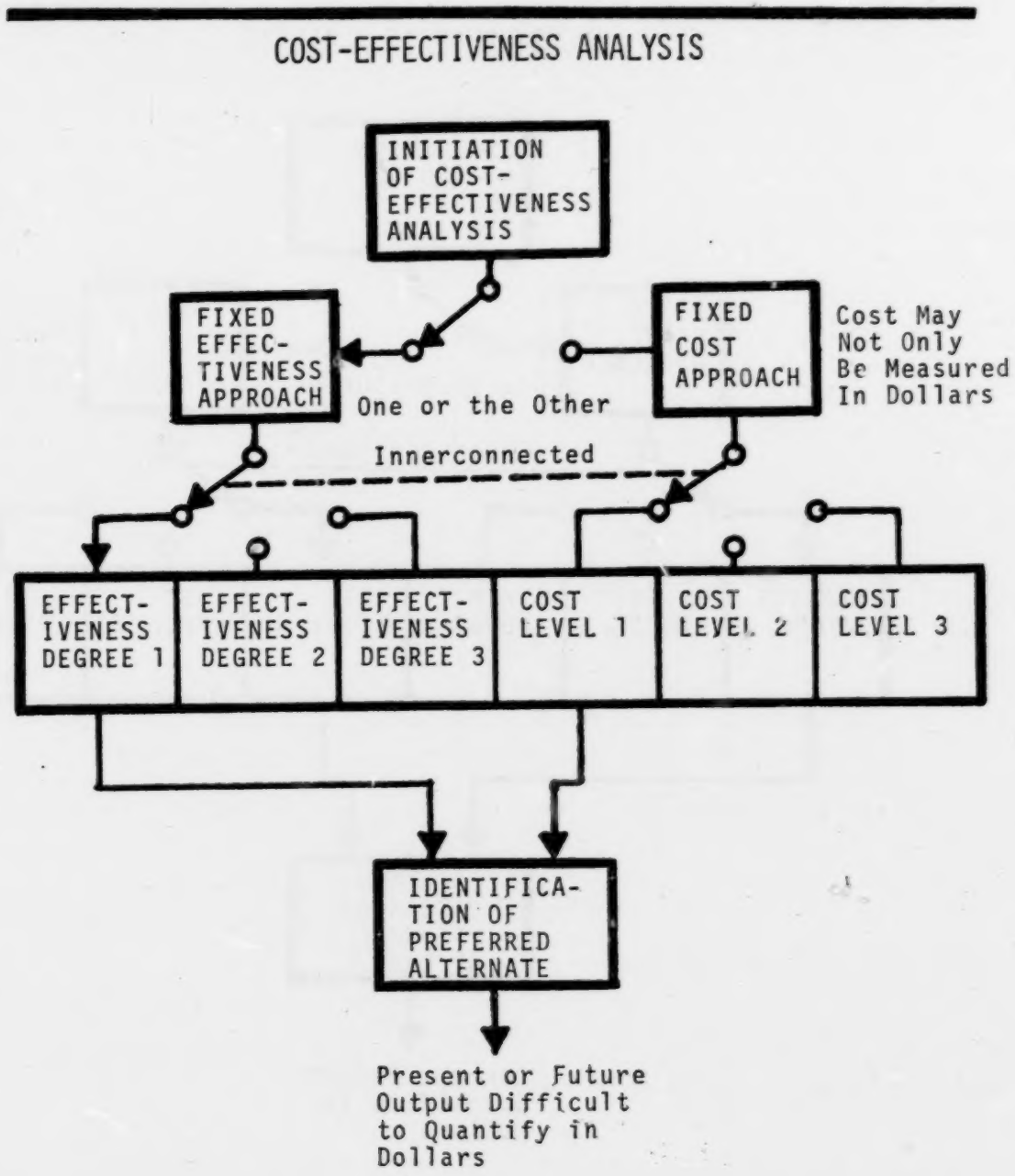
Confusion also exists concerning the difference between cost-effectiveness analysis and cost-benefit analysis (Fisher, 1967, p. 66). The prinicpal differences in these two methods are the elements of output and of time-phasing. These differences are diagramed in Figures 1 and 2.

Output

The term "cost-effectiveness" usually applies to situations in which it is difficult to quantify the alternate outputs in terms of dollar values. Cost-benefit usually considers only the monetary worth of outcomes.

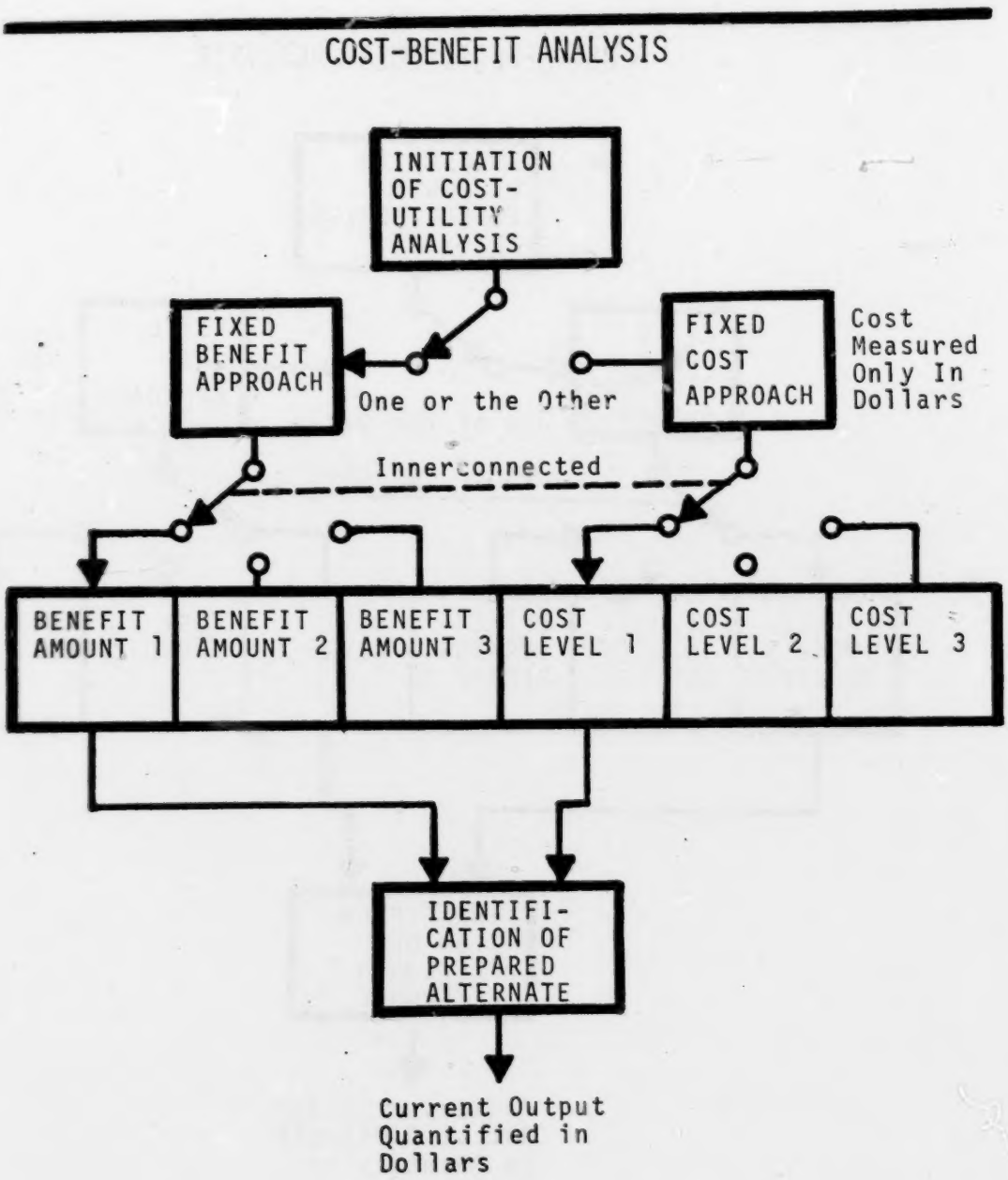
Time Phasing

The term "cost-effectiveness" is usually used to select the most appropriate choice from the predicted alternative outcomes; the term "cost-benefit" is most often applied in selecting the most appropriate choice from the calculated present (McGivney and Nelson, 1969, p. 105).



Note: After Pearson, 1972, p. 22

Figure 1. Cost-Effectiveness Characteristics



Note: After Pearson, 1972, p. 23

Figure 2. Cost-Benefit Characteristics

SUBJECT APPROPRIATENESS

Certain prerequisites should be met before a subject is appropriate for cost-effectiveness analysis (Kazanowski, 1968, p. 114). The primary appropriate prerequisite is that the subject should have two characterisitcs: first, and most important, the subject must be relevant; second, but less important, it should be capable of being measured both in required resources and outcome. These two characteristics often appear conflicting. The most relevant phenomena or events are often very difficult to measure, the least relevant are usually easy to measure (Niskanen, 1969, p. 20). Cost-effectiveness analysis should be performed only when the following appropriate prerequisites are met:

- The correct problem must be recognized.
- Realistic objectives that bear a functional relationship to the problem must be determined (Jakobsberg, 1966, p. 38).
- Common goals, objectives, or missions of the alternative must be identifiable and at least theoretically attainable.
- Constraints for bounding the problem must be discernible.
- Alternative means of meeting the goals must exist (Kazanowski, 1968, p. 114).

The meeting of these requirements is not always simple; consequently, if there is no freedom of choice in problem solving, cost-effectiveness analysis is not appropriate (Jarrett, 1967, p. 8).

RELATIONSHIP TO SYSTEMS ANALYSIS

In order to place cost-effectiveness in proper perspective, it is first necessary to place it in relation to the systems analysis process. Cost-effectiveness analysis is not a method for measuring either cost or effectiveness after the fact, for its modern applications are concerned with the prediction and evaluation of an alternative's worth (English, 1968, p. 7). The term "systems analysis" is used to distinguish this broader analysis from a narrow cost-effectiveness aspect of analysis. Cost-effectiveness analysis is that aspect of systems analysis which emphasizes the systematic investigation of the decision-maker's alternatives relative to objective criteria, costs, and effectiveness comparison, in addition to the other trade-off

factors associated with alternative selection (Quade, 1969, p. 3). Figure 3 graphically illustrates this emphasis.

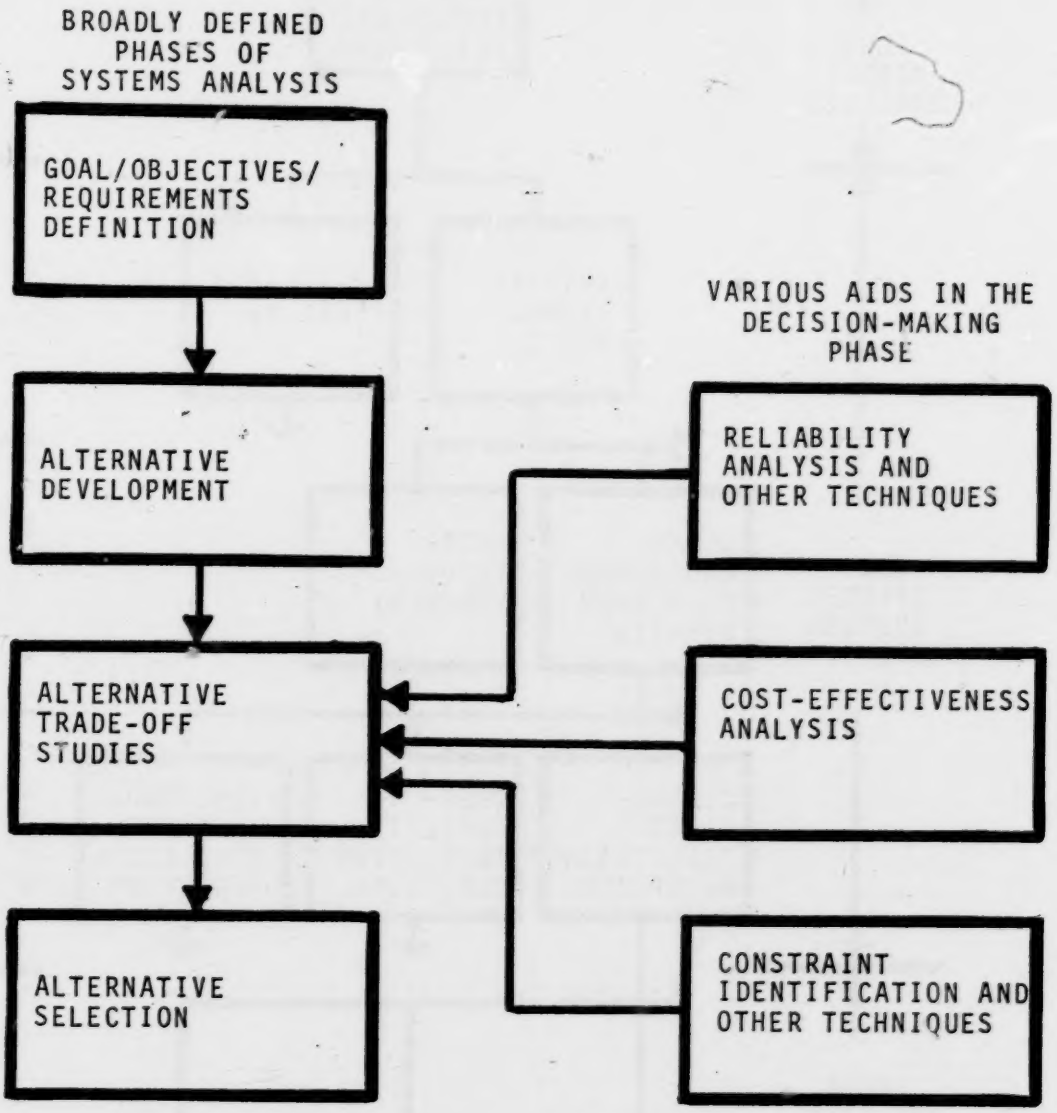
> It can be seen, then, that the difference between cost-effectiveness analysis and systems analysis is a matter of emphasis. If the emphasis is on finding significant differences in the costs or resource requirements among the available alternatives for carrying out some specified task, the analysis is gnerally referred to as a cost-effectiveness analysis. The systems analyst, on the other hand, is likely to be forced to deal with problems in which the difficulty is deciding what ought to be done, not simply how to do it. System analysis thus puts greater emphasis on the suitability of the task and the augmentation of alternatives. In both system-analysis and cost-effectiveness work it is important to note, however, that after an appropriate evaluation one will be in a much better position to make a decision, even though he may not find the decision easier to make (Bell, 1964, pp. 1-2).

CATEGORIES

The confusion over the role cost-effectiveness analysis plays in the systems analysis process seems to arise from the fact that some practitioners perceive cost-effectiveness analysis to be the systems analysis process itself; whereas, others see the process of cost-effectiveness as being related to and a sub-set of the total systems design process. As noted above, both interpretations of the role of cost-effectiveness analysis could be appropriate, depending upon the time and conditions that the analysis requires. There are, however, three categories of cost-effectiveness analysis which, in practice, are not clearly distinct. These categories are: (1) system/component configuration study; (2) system comparison study; and, (3) suprasystem comparison study (Heuston & Ogawa, 1966, p. 245). The relationship of these categories is exhibited in Figure 4 and a detailed description follows.

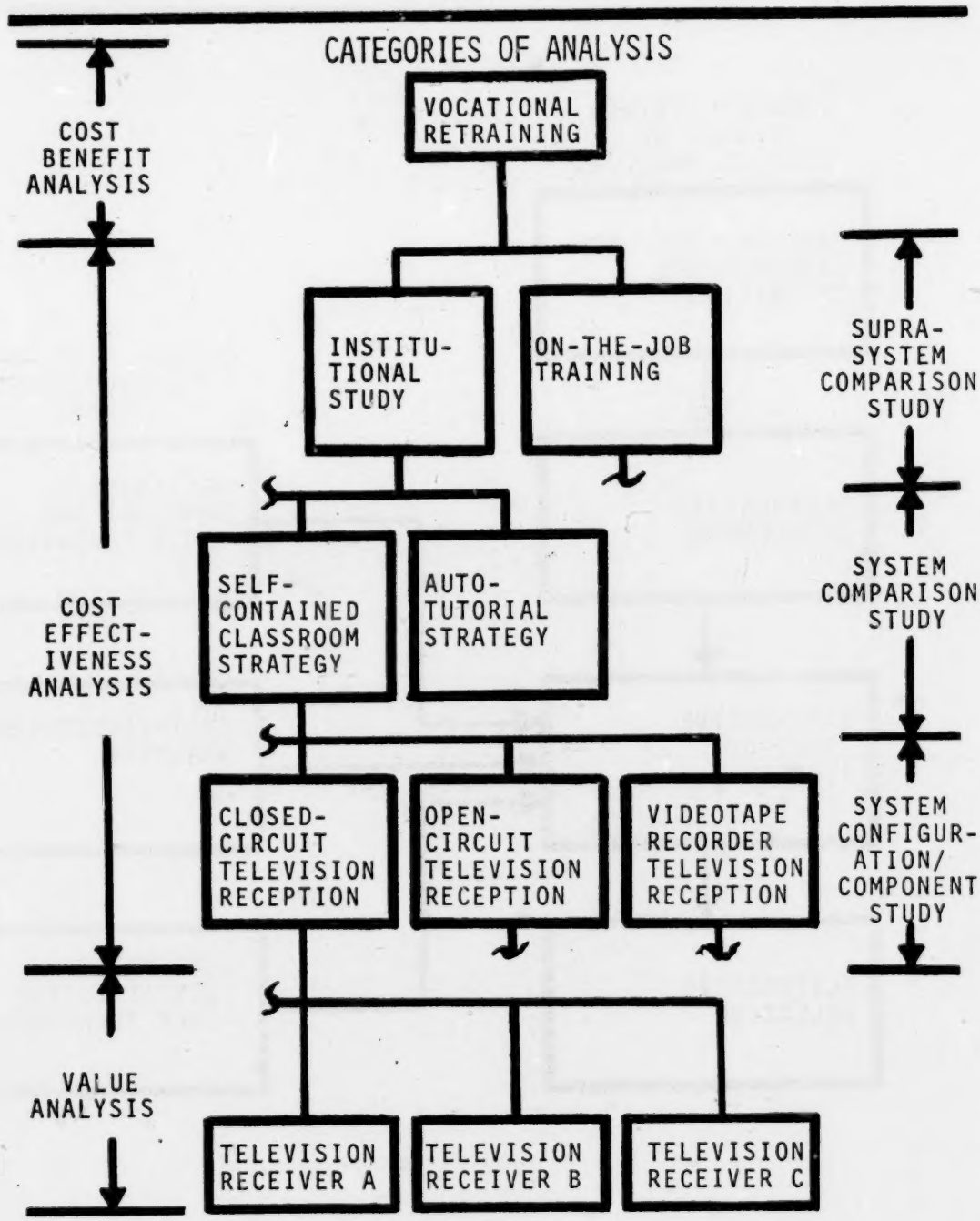
Systems Configuration/Component Study

In this category the emphasis is on the selection of the particular configuration, or characteristics, of a single system with different components. For example, a closed-circuit instructional television system versus an open-circuit instructional television system. This category of study is probably the one most often performed.



Note: After Heaton, 1969, p. 35

Figure 3. Relationship to Systems Analysis



Note: After Pearson, 1972, p. 29

Figure 4. Categories of Analysis

Cost Treatment. Typically, system/component configuration studies have the following characteris ics relating to the treatment of costs:

- Detailed costs are obtained on all components.
- Various mathematical models are used to simulate and optimize different possible configurations of the components. The results yield the predicted overall costs of the various alternatives under study.
- Costs are compiled by summing the yearly costs over the life cycle of the systems rather than by compiling time-phased costs.

Effectiveness Treatment. As in the treatment of cost, the effectiveness measure used in the system configuration/component study will be detailed in terms of capabilities and performance. In most cases, effectiveness will not be a simple overall measure which ultimately would determine alternative selection (Hatry, 1969, pp. 45, 47-48).

It should be noted that trade-off analysis at the detail level of selecting subcomponents is classified as value analysis rather than cost-effectiveness analysis (Kazanowski, 1968, p. 153). An example of this type of analysis would be the selection of the least expensive instructional television receiver that complies with given specifications.

System Comparison Study

Here, the emphasis is on comparing two or more systems for the same objective. The emphasis is on intersystem, not intrasystem, analysis. It is presumed that each competing system has already been sub-optimized as to its configuration, through the system/configuration component study discussed previously. An example of this type of study would be to compare the merits of a programmed-instructional system versus an autotutorial system (where each has been instructionally validated).

Cost Treatment. Typically, the system comparison study has the following characteristics relating to system costs:

- Costs are generally required in less detail than in system/component configuration studies where the emphasis was on components of competing similar characteristics.

- The specific spread of costs over the life cycle of the system is usually ignored, or is treated as a secondary problem.

Effectiveness Treatment. The effectiveness measure is basically quite similar to that used in system/component configuration studies.

Suprasystem Comparison Study

This third cost-effectiveness study category is less frequently performed as a strictly cost-effectiveness activity. Activities at this level of analysis are usually described as cost-benefit. The problem here is to assess the merits of alternatives of widely differing capabilities and cost elements. An example would be to analyze the cost-effectiveness of competing instructional systems such as institutional study as opposed to on-the-job training.

Cost Treatment. In suprasystem comparison studies, costs are each time-phased to the extent possible, to provide estimates of annual resource requirements (Hatry, 1969, pp. 48 & 50).

Effectiveness Treatment. The determination of a measurement of effectiveness is especially difficult for those cases where the systems are experimental, the objectives are of unequal priority, and the output varies in type and reliability (Heuston & Ogawa, 1966, p. 245).

The problem of the analysis of differing costs and capabilities of alternatives requires the development of some measure of structure for comparing these alternatives on a somewhat equal basis (Department of Defense, 1971, p. 5).

PROCESSES

In addition to the confusion from the differences of cost-effectiveness analysis categories, differences in the process of the analysis itself has compounded the lack of understanding. Yet, in all the variations, two processes are performed: (1) the procedural process; and, (2) the application process.

Procedural Process

This cost-effectiveness analysis process can be defined as the documentation or writing of instructions on how to perform the analysis in a step procedural sense. This type of process is also known as model building; i.e., a conceptual mock-up or detailed paper-pencil description of the actual analysis to be performed at some later time.

Application Process

The second cost-effectiveness analysis process refers to the application of the procedural process by applying a particular model to a real-world practical situation (Speagle, 1969, p. 22).

STANDARD PROCEDURE

The chief value of cost-effectiveness analysis is its broad ability to provide a general framework to assist in the solution of problems in a wide range of topical areas. Cost-effectiveness analysis differs from many other decision-assisting tools which are limited to accepting only certain classes of problems.

The very fact that cost-effectiveness analysis can assume characteristics dictated by a unique objective and respond to the category, level, and process of analysis as required provides a lack of uniformity in the analysis itself (Jakobsberg, 1966, p. 37). In addition, the apparent lack of uniformity in most examples of cost-effectiveness analysis, and the lack of consistent documentation, has led some persons to question the merits of this type of analysis as an aid to decision-making (Kazanowski, 1968, p. 113).

On the other hand, certain authors and authorities in the field indicate that a complete "how-to-do-it" document, or a "cookbook," would be impossible to prepare (Jakobsberg, 1966, p. 37). This may be because, at the current stage of development, cost-effectiveness analysis is more an art than a science (Fisher, 1967, p. 70). Nevertheless, it is suggested that the majority of approaches to cost-effectiveness analysis have certain common functional elements which may be synthesized into a standard procedural approach. These steps are illustrated in Figure 5 and include the following inputs from others, analysis, and outputs:

- Step 1. Review definition of the desired general goals and specific objectives that the design is to meet or fulfill.

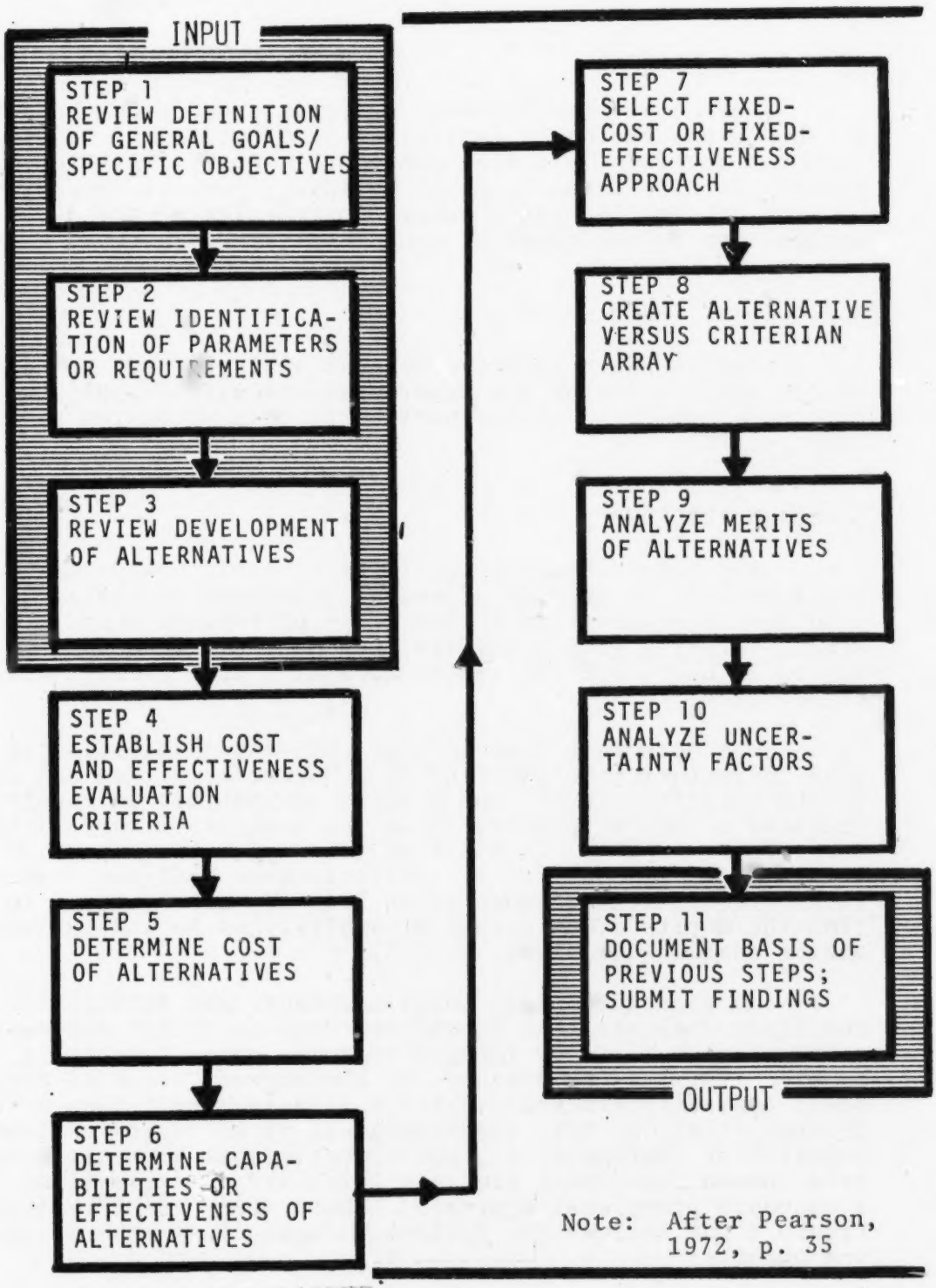


Figure 5. Standard Procedure for Analysis

- Step 2. Review identification of the parameters or requirements essential for the attainment of the desired goals/objectives.
- Step 3. Review development of the alternatives for accomplishing the goals/objectives/requirements.
- Step 4. Establish an evaluation criteria (measures), for cost and effectiveness, that relate alternative capabilities to the goals/objectives/requirements.
- Step 5. Determine the cost of alternatives in terms of evaluation criteria.
- Step 6. Determine the capabilities or effectiveness of the alternatives in terms of evaluation criteria.
- Step 7. Select fixed-cost or fixed-effectiveness approach.
- Step 8. Create an alternatives versus criterian array.
- Step 9. Analyze the merits of alternatives.
- Step 10. Analyze the uncertainty factors.
- Step 11. Document the rationale, assumptions, and analyses underlying the previous steps and submit findings (Pearson, 1973, p. 34).

The following discussion of these procedures suggests guidelines to be followed for a standardized approach to the analysis of system/cost-effectiveness. Although the presented steps are in an order in which they would usually be performed, changes in the sequence are acceptable and should fit the need of the subject under evaluation (Kazanowski, 1968, pp. 115-116).

Step 1

Review definition of the goals/objectives. Before cost-effectiveness analysis can be considered, the problem must be identified and the goals/objectives must be defined, at least in a general nature. Obvious as this may seem, the perception of the problem that needs solving, and the establishment of goals and objectives, are very often complex and involved tasks for which there are no techniques and tools besides "logical

thinking" (Jakobsberg, 1966, pp. 37-38). Without such an identification of goals/objectives there is no framework for structuring the subsequent evaluations. The following are several points to consider in reviewing the general goals/objectives definition.

If goals/objectives specified are in too general terms, the constraints established for bounding the evaluation are often only the product of the analyst. In addition, care must be exercised not to identify the goals/objectives in such a manner as to bias the evaluation by including requirements of such specific nature that they exclude potential candidate alternatives from consideration. On the other hand, care must also be taken not to make goals/objectives too specific or they will limit the scope of possible candidate alternatives by implicitly defining alternative concepts rather than just the desired goals/objectives. A potential danger always exists in that the goals/objectives originator may specify a goal/objective that is unattainable by means of current technology.

Step 2

Review the identification of the parameters or requirements. The basic purpose of identifying and defining the general goals/objectives is to aid in the identification of requirements essential to attaining the defined goals/objectives. The goals/objectives and requirements should be identified and specified within the required parameters. This specification is used to further reduce the possibility of biasing the cost-effectiveness analysis. The confusion brought about by close relationship between goals/objectives and requirements is further compounded by the variety of categories of cost-effectiveness studies (i.e., suprasystem comparison study and system configuration/component study). The need for detailed specificity can be illustrated by the following simplified example of the general goal/objective of eliminating poverty of migrant agricultural workers by vocational skill training. One requirement would be the identification of current labor market vocations needed so that detail job performance training specifications could be formulated. The resulting requirement specification might detail tool or machine operator competencies needed, as well as conditions and level of performance expected after training completion. The major factors for consideration when reviewing the identification of goals/objectives and requirements, and the development of specifications are as follows.

- Verify the establishment of a relationship that converts goals/objectives into some unit of measure for both cost and effectiveness. For example, number completions at a given level of achievement.

- Be alert for errors of commission, which are just as important as errors of omission. If goals/objectives that are not necessarily essential are identified as requirements, they can strongly prejudice the subsequent cost-effectiveness evaluation (Kazanowski, 1968, pp. 117-119).

Step 3

Review development of the alternatives. As in defining the goals/objectives and identifying the requirements, developing valid alternative means or courses of action that can satisfy the goals/objectives is a mental exercise for which no current scientific technique exists (Jakobsberg, 1966, p. 39). This activity is to create two or more alternative concepts of ways to achieve the goals/objectives within the defined parameters or specifications. Frequently, considerable imagination and creativity are required to develop effective competitive candidate alternatives. The results of cost-effectiveness analysis can be no better than the conception and development of attractive candidate alternatives (Kazanowski, 1968, p. 120).

There are several problems associated with the review of the alternative development. The most serious problem or source of defects is attention bias. This is frequently caused by a cherished belief or an unconscious adherence to what we might call a "party line." This attention bias may result in the unwarranted favoring of a particular alternative by the analyst (Quade, 1969, p. 8). Another problem is the degree of detail associated with available information on alternatives. Since the purpose of cost-effectiveness analysis is to aid the decision-maker in deciding which alternative should be selected, specific details on possible alternatives are generally lacking. Too little detail usually results in a large variance in estimated alternative effectiveness and cost. On the other hand, to require that the candidate alternative be designed in detail, before being evaluated, would defeat the basic purpose and value of cost-effectiveness analysis. In addition, the development of new and novel alternatives might be discouraged by detail design requirements. This factor would tend to favor existing or more traditional alternatives. The balance between inadequate detail and excessively rigorous specificity should be maintained.

Step 4

Establish cost and effectiveness evaluation criteria. The criteria specifies: (1) the measure of cost; (2) the measure of effectiveness; and, (3) the relationship between

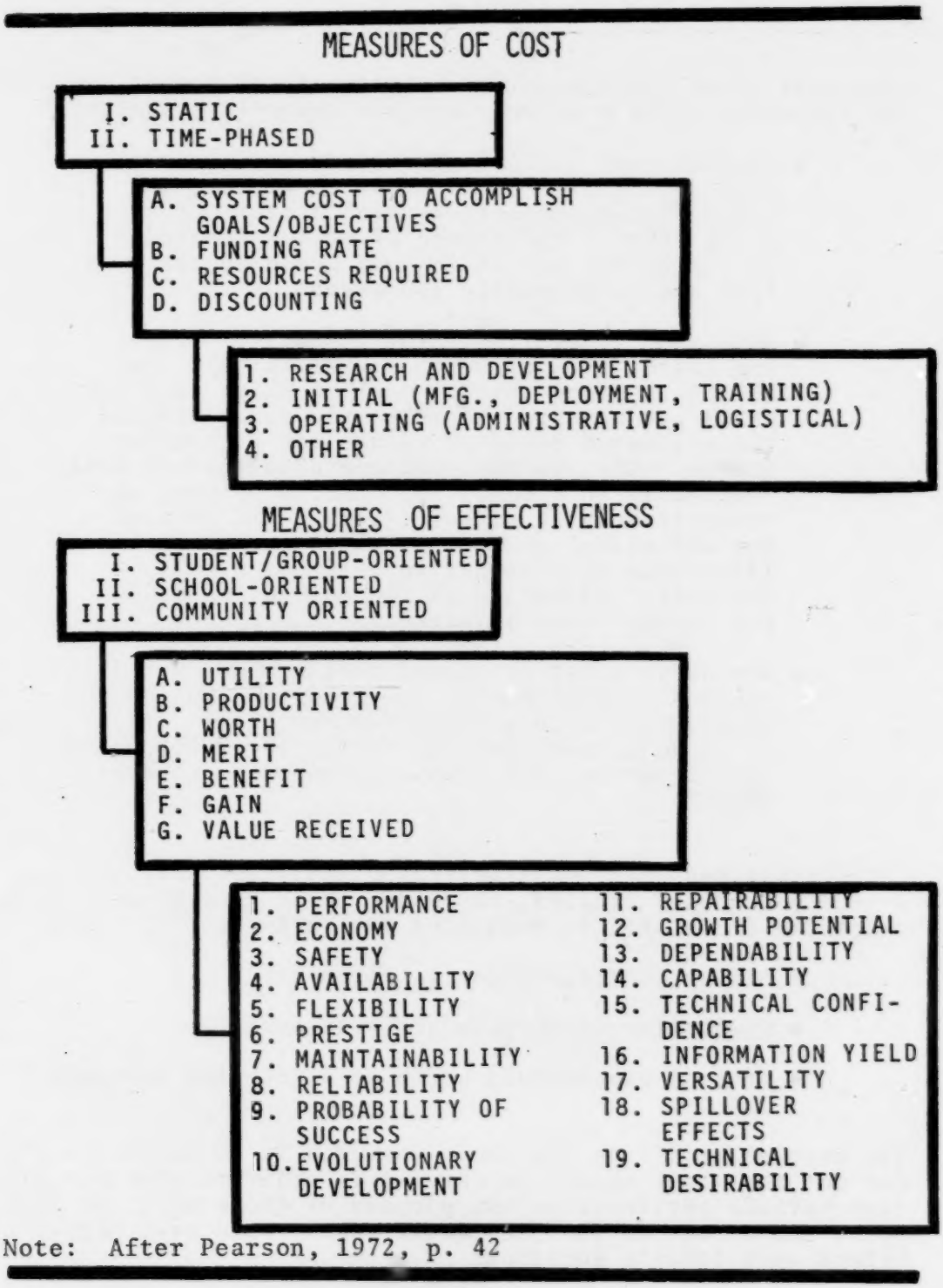
them. All will be used in the selection of one alternative from the several alternatives. The measure of cost must be consistent with the overall framework of the resource allocation problem; e.g., net future total cost of ownership for a certain number of years. The measure of effectiveness should express the extent to which the goals/objectives and requirements are being accomplished. The relationship between the cost and effectiveness must be expressed in functional terms; e.g., in a mathematic equation, graphic display, or model (Bryk, 1965, p. 1).

The selection of appropriate and adequate cost and effectiveness evaluation criteria is based on judgment and experience. The omission of significant criteria could readily invalidate the results of a cost-effectiveness analysis. The inclusion of numerous criteria to be on the safe side, however, can result in mental paralysis when the optimum alternative selection is being made. The greater the number of criteria, the greater the probability that even unlikely candidates will excel in some criterion, making alternative system selection difficult. One simple test of the adequacy or completeness of cost and effectiveness evaluation criteria is to question whether one alternative could excel in most of the criteria established and still not be selected as the preferred choice. If the answer is affirmative, important criteria could be missing. Considerable insight into the subtleties of the goals/objectives and requirements is usually necessary for the establishment of meaningful alternative evaluation criteria (Kazanowski, 1968, p. 123). Certain evaluation criteria of cost and effectiveness suggested by a variety of authors are shown in Figure 6.

Substep 4.1

Develop measurers of cost. The choice of a particular alternative for accomplishing the goals/objectives implies that certain specific resources will be consumed and could no longer be used for other purposes. These are the costs. In future time period analysis most costs could be indicated as money expenditures, but their true measure should be expressed in terms of the values of alternative opportunities which are precluded because of this expenditure (Quade, 1969, p. 4). One of the most difficult problems in establishing cost evaluation criteria is the determination of appropriate cost measures. The choice of the proper cost measure involves both difficulties and controversy within the broad categories of time-phased analysis (cost distributions over extended time periods) and non-time-phased analysis.

Cost Measures for Non-Time-Phased Analysis. For the purpose of non-time-phased analysis (such as applied to the system/



Note: After Pearson, 1972, p. 42

Figure 6. Cost and Effectiveness Evaluation Criteria

component level configuration or system level comparison study) the following three cost measures are commonly suggested.

- Initial cost (including research and development and initial investment, to achieve the assumed goals/objectives plus X years of operating costs. The choice of what X should be is a problem, but it is most commonly taken as five and occasionally ten years.

- Adjusted initial cost plus X years of operating costs. The difference here is only the use of adjusted initial cost in which case the costs are adjusted to take into consideration the estimated residual values for each alternative. The residual-value problem occurs most frequently when comparing choices between alternatives which either: (a) could be used for additional goals/objectives; or, (b) the life-cycle of alternatives differs widely. The latter situation is the most often cause for initial cost adjustment.

- The above first or second cost measure but discounted in some manner. Discounting has been used in order to perform two functions: (1) as an adjustment for the increasing time period uncertainties; and, (2) to indicate economic impact.

Cost Measures for Time-Phased Analysis. For the supra-system comparison studies, there are three general cost measures suggested to be used in examining each alternative. These are:

- Annual funding/budget requirements.

- Cumulative funding/budget requirements.

- Present expenditure worth at a selected discount rate.

The problem in all of the above measures is to determine how far out the study should be carried in order to consider all time periods pertinent to the purpose of the study. At some point the effect of the subsequent years would have negligible effect upon today's decisions.

The is probably no ideal answer to the question of the cost measure to be used, in either time-phased or non-time-phased

analysis. No single cost measure incorporates all pertinent elements and it may well be desirable to use more than one measure to give the proper cost perspective (Hatry, 1967, pp. 64-67).

Substep 4.2

Develop measurers of effectiveness. Of all the components or constituents of cost-effectiveness analysis the cost-measure concept has found the least acceptance as a valid measurement criterion. Less difficult was the acceptance of the effectiveness-measure criterion (Breckner, 1967, p. 83). Proper effectiveness criteria selection, however, is one of the most formidable problems of cost-effectiveness analysis. If the goals/objectives are not trivial, then real world facets are generally complex and have widespread implications; consequently the effectiveness criteria may be broad and numerous. If the scope of the goals/objectives is reduced, usually so is the number of significant criteria. Even if the scope of the problem is significantly reduced, it is virtually impossible to reduce the total cost-effectiveness analysis to a single easily evaluated effectiveness criterion (Kazanowski, 1968, p. 152). On the other hand, the more narrow and fewer in number the measure of effectiveness criteria become, the more limited will be the eligible alternatives to be considered. It is often desirable, therefore, to broaden a cost-effectiveness analysis study to include more effectiveness criteria in order to insure a wider range of alternatives (Breckner, 1967, p. 58). Well-defined and explicit measures of effectiveness are difficult to develop and rare. Typically, these measures are replaced by two devices: (1) performance identifiers; and (2) standards.

Performance Identifiers. These effectiveness measures relate to the administrative control of functions where output is inadequately defined. Usually, performance measures are specified on an activity basis to give an estimate of work performed. The performance identifier tends to be a device to measure work performance and is designed to detect the variations in work performance levels. In fact, however, performances may have little relation to the final output.

Standards. These effectiveness measures are much broader than performance identifiers. Government procurement activities are characterized by the use of standards, which may be of two types: technical performance standards, and generalized standards.

Considerable overlap exists, however, and many problems are common to both.

- Technical performance standards exist throughout government and industry and are needed to give a vital measure of uniformity and interchangeability of parts, components, assemblies, and processes. For example, both the government Bureau of Standards and the industrial Underwriters Laboratories develop operational and performance standards for electrical items. These standards are observed by those manufacturers who wish to market products in the United States.

- Generalized standards are identified to distinguish them from technical, and are used when specific output and effectiveness measures are difficult to determine. For example, certain accrediting organizations develop guidelines and standards for the evaluation and certification of public schools, academic institutions, and libraries. These standards are observed and maintained by those wishing accreditation (Teitz, 1968, p. 309).

Unique to instructional design are three broad categories of instructional effectiveness measures: (1) student/group-oriented, (2) school-oriented, and (3) community-oriented.

Student/Group Oriented Measures. These effectiveness measures refer to academic achievement change (grades) resulting from an improvement in the instructional program.

School-Oriented Measures. These effectiveness measurers are characterized by three types.

- The change in number dropping out of school as a consequence of these achievement changes in a given school population in terms of changes.

- The number selecting the various available courses of the study.

- The number and quality of those graduating (as indicated by scores on standardized tests).

Community-Oriented Measures. These effectiveness measures are characterized by two types.

- The average expected lifetime earnings potential of persons with different levels of education (economic factors).
- The reduced relationship between parental socioeconomic level and individual achievement indicating increased equality of educational opportunity (social change) (Abt Associates, Vol. I, 1967, p. 3).

Although not applicable in all circumstances, the following ground rules may be observed in selecting appropriate measures of effectiveness:

- Do not force a quantification measure of effectiveness where no sound analytical basis for it exists.
- Some effectiveness criteria will be quantifiable, but many will not be.
- Nonquantifiable effectiveness criteria pose no particular difficulty in analysis when appropriate.
- When the analysis involves a mixture of quantitative and qualitative effectiveness criteria, the cost-effectiveness analyst must exercise caution in gauging the impact of the qualitative criteria. For this reason, quantitative criteria are usually preferred, and the result is interpreted in terms of the qualitative criteria (Jakobsberg, 1966, pp. 39-40).

A final consideration is to choose a measure of effectiveness which serves as a sufficient input to the next level of decision-making (Niskanen, 1969, p. 30).

A methodological consideration discussed in Step No. 4 dealing with measures of both cost and effectiveness is that no single criterion measure that is appropriate for all goals/objectives is known. Even if a single criterion measure is adopted for all goals/objectives, the present inability to quantify relationships suggests the use of a multidimensional scale for measuring results (Packer, 1968, p. 235).

Step 5

Determine cost of the alternatives. Cost and effectiveness of alternatives must be determined in order to rationally allocate resources. Costs are considered easier to determine than effectiveness because dollars, manpower, and materials are homogeneous and measurable. Accurately predicting future costs is not simple, however, because consideration must be given to uncertainty of cost estimates, the unpredictability of inflation, and to the probable time-value of money due to discounting. Other factors that could also be included are the cost of opportunities lost and the effect of uncontrolled consequences of the outcomes (Packer, 1968, p. 247).

The problem of dollar-cost estimating often assumes so much importance in any cost-effectiveness analysis that the usefulness of the basic concept of cost (as it relates to the analysis) is lost. As a result, accounting/budget costs may take on an importance which may not be justified. It should be remembered that costs as prediction of the future can only be estimates and we always estimate future values on the basis of past experience. As a consequence, it is natural that records of past experience are reviewed in order to project future costs. Since the accounting/budget costs records usually include some aspects of actual past costs, a critical review of these historical costs is recommended. This review is to ensure that past under or over cost expenditures will not prejudice the current cost estimate (English, 1968, p. 77).

The performance of Step No. 5 should deal with cost analysis for cost-effectiveness and similar analysis. The term "cost analysis," in one form or other, is also used for those involved in budgeting, accounting, and cost-control purposes. Although somewhat related, these methods are not considered here (Hatry, 1969, p. 44). In cost-effectiveness analysis, the development of highly detailed cost breakdowns are not required (Novick, 1967, p. 103). It should be also noted that the preparation of the cost estimate is usually performed by someone other than the cost-effectiveness analyst. It is axiomatic that the estimate cannot be better than the statement of the goals/objectives/requirements on which the cost estimate is based. These statements, however, sometimes reflect the cost estimator's own particular biased interests (Novick, 1963, p. 102). In the creation of a cost estimate in accordance with the goals/objectives/requirements, the cost-effectiveness analyst must verify that the cost estimator has provided the following cost data.

Identify Cost Categories. These categories cover the source of major costs (Herd, 1965, p. 81). Measures of cost (developed in Step No. 4) should be indicated as well as the following elements:

- Matter-energy, information, and time.
- Human effort (student time and effort, teacher time and effort, administrative or technician time and effort).
- Monetary costs (short run and long run capital and operating activities) (Miller & Rath, 1969, pp. 21-24).

Identify Resource Constraints. These constraints usually result in the indication that highly aggregated costs are useless; that costs must be broken down into relatively small units which will permit a variety of cost analysis approaches.

Calculate Costs. Each category indentified should be considered on an appropriate time basis as well as in total. (Although the alternative total cost may be within the total resources available, the annual expenditures may not be compatible with the budget or funding pattern.)

Identify Possible Cost Variance. A single cost estimate does not indicate unknowns relative to other costs provided by others. Unknown factors in cost data elements should be identified for subsequent uncertainty analysis.

Verify Completeness. Insure compliance of cost data elements with a checklist (Herd, 1965, p. 81).

Essential to the validity of all cost-effectiveness analysis is the availability of appropriate, accurate, and timely cost estimates. It is true that a poor cost-effectiveness analysis can misuse even the best cost data, but even the best of analysis cannot do much with inadequate cost data (Hatry, 1969, p. 55).

Step 6

Determine capabilities or effectiveness of alternatives. Once the effectiveness evaluation criteria have been determined (Step No. 4) the next step is to express the capabilities of the alternative systems in terms of the evaluation criteria. To save time, this is often performed concurrently with Step No. 5. Quantitative expressions of capabilities are preferred when they are available but qualitative expressions are acceptable when they are not (Kazanowski, 1968, p. 129). As in cost estimation, the estimates of the capabilities of alternative systems is

dependent upon information and data supplied by someone other than the cost-effectiveness analyst. Although this is both an advantage as well as a disadvantage, confidence in the accuracy of alternative system capability may be lacking and may be subject to the biased interests of the estimator (Quade, 1969, p. 10).

Step 7

Select fixed-cost or fixed-effectiveness approach. In assessing alternatives, the procedure may now take either one of two analytical approaches:

- A desired level of effectiveness may be specified, and the analyst seeks the most economical way to achieve it, or
- The level of expenditure may be specified and the analyst explores the effectiveness offered by the alternatives capabilities (Breckner, 1967, p. 43).

The choice of specifying either the fixed-cost or the fixed-effectiveness analysis approach oftentimes is the option of the analyst. This choice is important because, in most cases, real-world problems cannot be adequately dealt with in such a simple form as optimizing either cost or effectiveness. This is because in most studies unique measures of cost and measures of effectiveness can only be obtained by directing the analysis on a very small aspect of the total goals/objectives and requirements. The results of such as analysis is rather superficial and seldom reflects the real-world goals/objectives and requirements from which the decision-maker must select the best alternative. The selection of one approach, therefore, may more closely reflect the real-world options actually available to the decision-maker, whereas the selection of another approach might reflect options which are not available. Another factor in the choice of one approach over the other may also yield economies of analysis, depending on the availability, quality, and validity of data to be utilized in the cost-effectiveness analysis itself. The choice of fixed-cost or fixed-effectiveness approach is least affected by the constraints imposed by the decision-maker, therefore, the choice of approaches is vital to the integrity of the analysis.

Fixed-Cost Approach. A basic fixed-cost approach is first, the development of alternative systems that can compete in meeting the goals/objectives/requirements (Step No. 3) in competition for the given resources. Second, the number of components

of each alternative that can be developed, procured, and operationally implemented within the fixed resources, is determined. Finally, the alternative which satisfies the goals/objectives/requirements to the greatest extent is identified as the preferred choice.

Fixed-Effectiveness Approach. A basic step in the fixed-effectiveness approach is first, development of a measure of the effectiveness expressed in terms of the requirements identified in the prior Step No. 2. Then, alternatives are developed to meet the goals/objectives as in Step No. 3. The number of components of each alternative necessary to attain the goals/objectives is determined and, the costs and penalties incurred by each alternative are estimated. Finally, the alternative that exhibits the least aggregate cost penalty is identified as the preferred choice.

It is suggested that if inflexible constraints are imposed on the resources available, the use of the fixed-cost approach is indicated. Conversely, if inflexible constraints are imposed on the effectiveness required, the use of the fixed-effectiveness approach is indicated. In the absence of other guidelines, the presence of both a large number of significant measures of effectiveness criteria and a small number of measures of cost criteria usually indicates that the fixed-effectiveness approach should be used (Kazanowski, 1968, pp. 126-128).

Note that in using either the fixed-cost and/or fixed-effectiveness approaches to evaluate alternatives, the measure of criteria (either the cost criteria or the effectiveness criteria must be held constant so as to have a common basis for comparison). Methods in which both the measures of cost and the measures of effectiveness are allowed to vary are to be avoided because there would then be no common basis for comparison (Barfoot, 1963, p. 3).

Step 8

Create alternatives versus criteria array. Ideally, it would be desirable to examine the cost and effectiveness evaluation criteria of the alternatives in the real world rather than in the simulated world of cost-effectiveness analysis. For many obvious reasons, such as excessive expense and/or the unavailability of the alternatives, this is not possible (Blumstein, 1969, p. 33). Two different analytical techniques of conducting cost-effectiveness evaluations within either the fixed-cost or fixed-effectiveness approach are often encountered. These are: (1) the tabular display technique; and, (2) the model technique.

Tabular Display Technique. The tabular display technique is used when the alternatives are being evaluated by measures of cost, or measures of effectiveness, or by both measures of cost and effectiveness that are incommensurate with one another.

In this technique, the evaluation criteria underlying the analysis are identified at the tops of columns and arranged in decreasing importance of criteria from left to right as indicated in Figure 7. The alternatives are then listed vertically, with the alternative that meets the most significant criterion to the greatest extent listed first, and so on. This technique is useful when numerous alternatives are being evaluated because the technique can be used to eliminate the less likely competitive alternatives and allow attention to be focused on the two or three major competitors. Whether the fixed-cost or fixed-effectiveness approach is used, the tabular array created will be very similar. In the fixed-cost approach, major emphasis is placed on the effectiveness attainable; however, cost data indicating how the total cost is divided and phased is significant and should be shown. On the other hand, in the fixed-effectiveness approach, major emphasis is placed on the total cost. The advantage of the tabular display technique is that the orderly presentation of alternatives cost and capability data is permitted so that their impact on the evaluation can be readily discerned and discussed along with the significant interrelationships. Conclusions, therefore, can be reached by visible traceable means.

The Model Technique. The model technique, in which either cost models or effectiveness models are created, is usually used when the basic differences between the alternative systems are relatively minor, so as to permit the valid expression of their essential differences by a single parameter (Kazanowski, 1968, pp. 129, 134 & 136). These models may be structured along a spectrum of abstraction as shown in Figure 8. First, and the least abstract to be considered is the real-world system, within which the analyst cannot work. Next the more abstract models of this real-world are examined. This includes the technique of operational exercise, gaming, simulation, and analytical modeling. Last, at the opposite end of the spectrum, is total abstraction, within which, again, the analyst cannot work.

- Operational exercise technique. The closest approximation to the real-world would be an operational exercise, using the actual situations with the alternatives under study. Operational exercise differs from the real-world in that the scale is smaller and many of the personnel are simulated. In addition, the consequences of

COST TABULAR DISPLAY

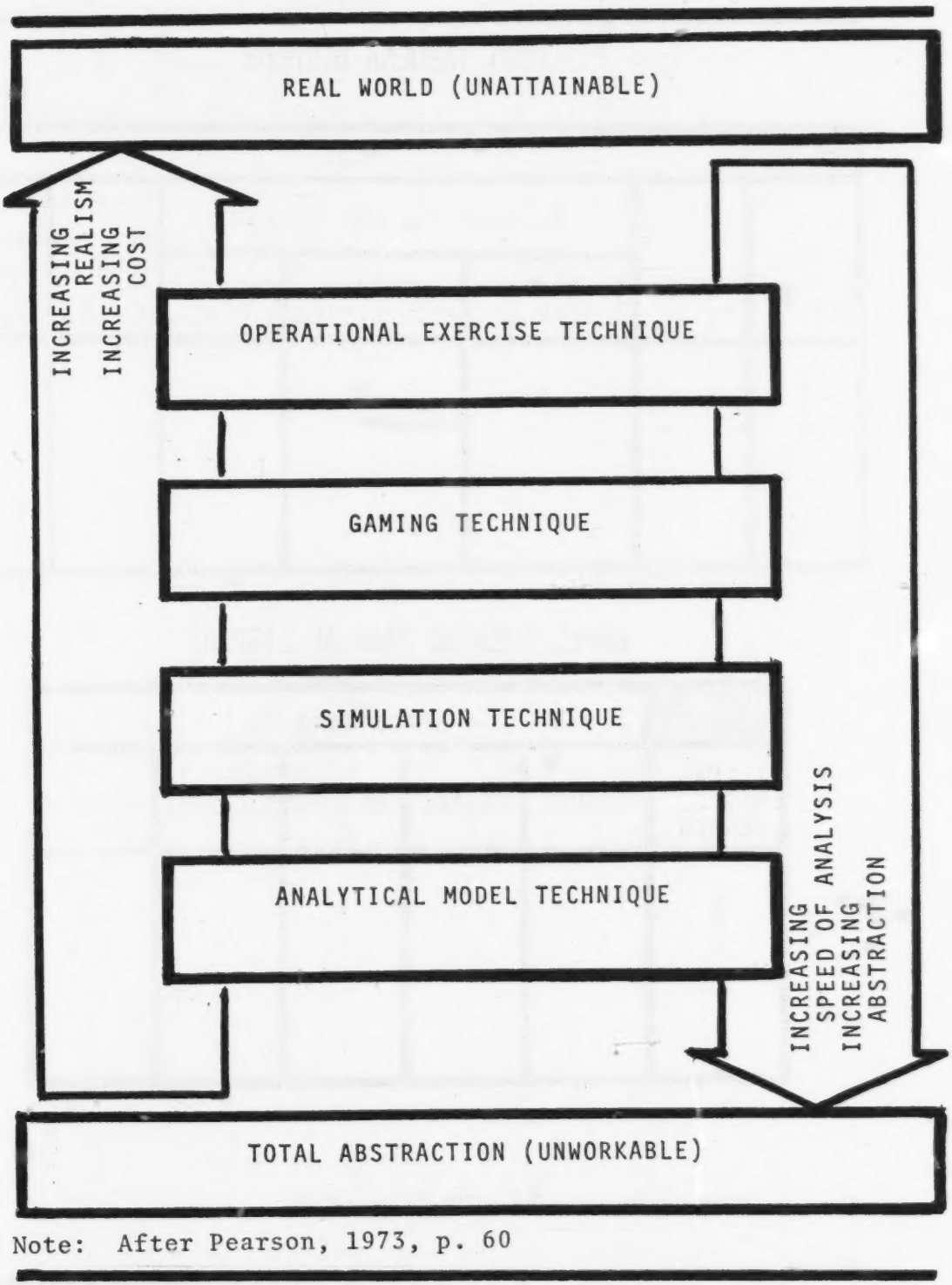
	COST					
ALTERNATIVE DESIGN	TOTAL	DOLLARS PER NO. YEARS			PERSONNEL REQUIRED	MATERIAL REQUIRED
		RESEARCH & DEVELOP	INITIAL/ ACQUISITION	OPERATIONAL		
X Y Z						

EFFECTIVENESS TABULAR DISPLAY

	EFFECTIVENESS				
ALTERNATIVE DESIGN	DEGREE 1	DEGREE 2	DEGREE 3	DEGREE 4	DEGREE 5
X Y Z					

Note: After Kazanowski, 1968, p. 132

Figure 7. Tabular Display Technique Example



Note: After Pearson, 1973, p. 60

Figure 8. Model Techniques Spectrum

failure are not considered. The operation exercise, consequently, is a very close approximation to the real alternative but contains certain factors that would not normally exist in the real world. The running cost of such an exercise is great and the number of alternatives which can be analyzed is small.

- Gaming technique. The next region down this spectrum of abstraction is gaming. Here are removed from the representation of the real-world those components that can most easily be simulated by a simple analog such as a computer or some other device.

- Simulation technique. The next stage towards model abstraction is to physically remove the human decision-maker from the representation. At this point the merits and operation of the alternatives are simulated on a computer in which the human decision rules are explicitly programmed.

- Analytical technique. In those models already considered, although modified or compressed, there has been relationships between time in the real world and time in the model. In analytical models, even this relationship is abandoned. Here a system of equations is created: (1) that relate the characteristics of the alternative; and, (2) that are related to the measures of effectiveness. Examples of this are linear programming models, graphic models, and the whole class of equations referred to as math models.

The model spectrum (Figure 8) represents, from top to bottom, increasing abstraction from the real-world; or alternately, proceeding from bottom to top in the figure, increasing realism or closer approximation to the real world. It is also generally observed that both the cost of the analysis and the rate at which we can examine different situations decreases as the model used becomes more abstract. For reasons of economy and completeness of analysis, we would like to operate as close to total abstraction on this spectrum as possible. On the other hand, the possibilities of faulty assumptions increases as we move away from working in the real world.

In exploring considerations that go into modeling technique selection for a particular cost-effectiveness analysis it should be remembered that the basic function of the model is to

determine the value of the measure of effectiveness when the controllable variables of the alternatives are used (Blumstein, 1969, pp. 34, 35 & 39). Here the term "model" is used in a broad sense. Depending on the nature of the goals/objectives, the model used in the cost or effectiveness analysis may be formal or informal, very mathematical or not so mathematical, heavily computerized, moderately computerized, or not computerized at all. The main point, however, is that the model need not be highly formal and/or mathematical to be useful. The following important points should be considered in the selection of modeling techniques.

- Remember that model building is an art, not a science. Often it is an experimental process.
- Emphasize those factors relevant to the goals/objectives, and suppress those factors that are relatively unimportant. The model is likely to be unmanageable if this is not done.
- Develop a meaningful set of relationships among: (1) goals/objectives, (2) the alternatives available for attaining the goals/objectives, (3) the estimated cost of the alternatives, and (4) the estimated effectiveness for each of the alternatives.
- Base the model design upon the "building-block" concept, which accepts analytical data prepared during prior steps in the creation of a set of smaller or partial models. Each small model will be used in the construction of a larger subsequent cost-effectiveness model (Packer, 1968, p. 236).
- Make provisions for explicit treatment of uncertainty (see Step No. 10) (Fisher, 1967, p. 72).

Within the spectrum of modeling technique (from concrete to highly abstract models), there are two techniques that are most appropriate for the evaluation of measures of costs and measures of effectiveness. It would seem that the choice should be dictated by the category of the cost-effectiveness study as well as the goals/objectives. This choice is between simulation and analytical modeling techniques. Although the apparent difference between these two techniques is sometimes small, an analytical model is generally more efficient if the goals/objectives can be stated in terms such that available mathematical or graphic techniques can be used to solve for an optimum solution (Packer, 1968, p. 235). Both analysis of cost and effectiveness may make use of analytical models to represent:

(1) each alternatives being analyzed, (2) its operating characteristics, and (3) the management concepts of its operation and logistical support. These models are normally structured so that any parameter, or combination of parameters, can be varied to determine the relative effect on the alternatives' total cost and effectiveness (Heaton, 1969, p. 35).

Model Considerations

There are several considerations which should be considered in the utilization of analytical models for both cost and effectiveness.

Cost Analytical Model Considerations. The cost model relates the goals/objectives/requirements and activity rates of the alternative, and of the personnel that operate and/or support it, to measures of cost (Bryk, 1965, p. 4). Mathematical cost models are the most frequently used to evaluate alternatives when goals/objectives can be mathematically formulated, when mathematical conditions can be met, and the solution can be computed (Miller & Rath, 1969, p. 18). The key advantage of the use of mathematical cost models is the speed with which a number of alternatives can be costed. While exhibiting significant advantages for specific applications, mathematical cost models also possess substantial limitations. Two major disadvantages are:

- In creating the cost model a number of implicit assumptions are made. After the terms of the initial equation are mathematically manipulated and condensed for efficient use, the initial elements of the cost are no longer visible. Thus, the analyst may forget his initial assumption and their limitations.

- Mathematical cost models are relatively inflexible and good basically for one concept and its minor variations. If a basic variation other than those accounted for by the model is to be costed, the model must be revised and possibly modified. This modification must be verified by comparison with conventional long-hand results and as a consequence, the advantage of mathematical cost modeling is lost (Kazanowski, 1968, p. 128).

To conserve time, cost modeling is often perfomred concurrently with effectiveness modeling (Bryk, 1965, p. 14).

Effectiveness Analytical Model Considerations. The effectiveness model relates: (1) the measures of effectiveness in achieving the goals/objectives to, (2) measures of the alternatives operational performance (Bryk, 1965, p. 2). The use of a mathematical effectiveness model is recommended when the alternatives under analysis are basically so similar that those evaluation criteria that cannot be readily validated, can be considered to cancel each other out. This leaves only the quantifiable and commensurable criteria for evaluation. It should be noted that this occurrence is relatively infrequent (Kazanowski, 1968, p. 129).

Analytical Model Computer Use Considerations. Analytic cost-effectiveness techniques have attained their present level of acceptance largely because of the availability of today's high-speed computers and the development of appropriate computer models. The analytical models permit the study of complete interactions and many alternatives heretofore too complex and time-consuming for manual or desk-calculator analysis (Bell, 1964, p. 2). Prior to these computer programs, the cost-effectiveness analyst had to choose among several hand models, which were often unwieldy and unrealistic, and the older prototype computer models. These older computer models were frequently inflexible and failed to give insight into how conclusions were related to the assumptions (Quade, 1968, p. 243). The computerization of current analytical models is warranted, however, only when the analysis of alternatives involves repeated computation of complex functions (or when the same sub-routines are performed repeatedly). In addition, computerized analytical models of advanced future alternatives are oftentimes of limited value because the expensive programming is time-consuming and soon obsolete by today's standards.

Concerning cost analytical modeling, if the model is simple, it does not need to be computerized: if it is complex, the maintenance of the computer model and associated documentation may become time-consuming and expensive. A possible compromise might be to computerize those portions of an analytical cost model that are not subject to frequent revision. In a study directly related to instructional cost modeling, it was indicated that complex mathematical modeling would be incompatible with the concept of instructional cost-effectiveness development. This concept was to develop a procedure that was easy to use and not voluminous (Institute for Educational Development, 1970, pp. 3-4). Regarding effectiveness analytical models, these are seldom mathematical and as a consequence, computerization is seldom applicable.

Analytical Model Handbook Considerations. Rather than computerize generalized all-purpose analytical models, it has

been found more functional to compile an analytical costing and effectiveness handbook. Graphical displays of cost and effectiveness relationships, along with their underlying goals/objectives/requirements and assumptions, can be readily compiled and utilized. The handbook both allows and makes publicly visible the exercise of judgment to ascribe the impact of subtle deviations from a basic or common design on the cost and effectiveness of various alternatives. The costing/effectiveness handbook also has the virtue of simplicity, speed, flexibility, and economy (Kazanowski, 1968, pp. 131-132). The Institute for Educational Development has developed such a handbook, for alternative instructional design selection, under contract for the Bureau of Naval Personnel and naval training schools (Institute for Educational Development, 1970, p. 1). This two-part document is noteworthy in both volume and level of detail. Another approach in the development of an analytical model handbook is a document distributed by the Department of Defense (Department of Defense, 1969, p. 1). This both outlines the procedure of analysis and encloses analytical forms to be used.

It should be emphasized the cost-effectiveness models can never be completely realistic for they are dependent on too many uncertain parameters. The reliance on expert judgment is indispensable to all analysis. Moreover, the virtue of cost-effectiveness analysis is the provision of a framework that allows the judgment and intuition of specialists in diverse fields to be combined. This framework is the analytical model which represents a simplified, stylized representation of those aspects of the real world as appropriate to the goals/objectives (Quade, 1968, pp. 243, 246-247).

Step 9

Analyze merits of alternatives. In this final step, the integration of the previously derived alternative cost and effectiveness analytical models is performed. The purpose of the integration is to combine the expected values of alternative cost and effectiveness into a single common framework (Seiler, 1969, p. 71). This framework may be based on either the tabular display technique or model technique discussed in Step No. 8.

An example of the tabular display technique is found in Figure 9. This figure is, in addition, an example of the application process of cost effectiveness analysis (previously discussed) in which the analysis is both structured and evaluation is completed. This display was developed consistent with information provided by a cost and effectiveness input similar to that found in Figure 7. The instructional designs under study represents a variety of alternatives for in-service employee training. These alternatives are listed in order of recommended

RECOMMENDED INSTRUCTIONAL DESIGN FOR EMPLOYEE TRAINING IN ORDER OF PREFERENCE ACCORDING TO COST-EFFECTIVENESS SELECTION CRITERIA

	SELECTION CRITERIA						
ALTERNATIVE INSTRUCTIONAL DESIGN	ECONOMY	FLEXIBILITY	ADMISSION STANDARDS	EMPLOYEE ACCEPTABILITY	EMPLOYER ACCEPTABILITY	SPEED	TOTAL NUMERICAL EVAL.
DAY-RELEASE COURSES	1	6	5	5	3	6	26
FULL TIME SCHOOL	5	5	4	4	2	1	21
SANDWICH COURSES	4	4	3	3	4	3	21
VOCATIONAL TRAINING	6	1	6	6	1	2	21
BLOCK RELEASE COURSES	3	3	2	2	6	4	20
EVENING CLASSES	2	2	1	1	5	5	16

Note: After Drouet, 1968, p. 221

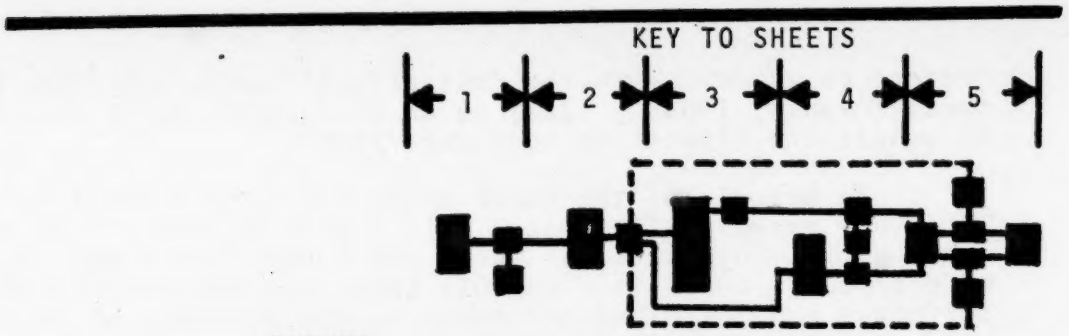
Figure 9. Tabular Display Example

preference according to the cost-effectiveness selection criteria (Drouet, 1968, p. 221) on an evaluative scale of 1 to 6 (6 equals the highest or most preferred).

An example of the model technique is presented in Figure 10. This example illustrates both a graphic analytical model and the procedural process (also previously discussed) of cost effectiveness analysis. In this case, the analytical model illustrates the logic and procedure of the analysis of each alternative instruction design for service training. The model indicates that each alternative instructional design may be characterized by: (1) instructional requirements, (2) instruction time, (3) course duration, (4) student achievement, (5) facility requirements, (6) number of courses per year, (7) equipment, (8) course development, (9) instructional materials, (10) software development, and (11) student and instructor travel time. In addition, each instructional design can be distinguished by: (1) student achievement, (2) student attrition rate, (3) student proficiency on the job after graduation, and (4) student morale. Attributes concerning student performance and morale, during instruction or later, are indentified as measures of effectiveness. This terminology is used because the effectiveness of the instructional design is measured in terms of the end products; i.e., student course completion. Other factors, such as instructor time per course and amount of instructional materials required are classified as measures of efficiency. The analytical model indicates that feasibility of the instructional design alternatives are determined initially. Next, the characteristics of the feasible alternatives are listed as well as the differences in the alternatives' effectiveness, efficiency, and costs. Risk factors are also considered in the analytical model. Last, the criterion for selecting the instructional design is applied (Institute for Educational Development, 1969, pp. 23, 25 & 26). This criterion is as follows:

> If the sum of incremental benefits in dollars of the new program exceeds its incremental benefits in dollars of the new program (sic., instructional disign) . . . exceeds its increase in incremental costs (with acceptable risk) then the new program is ranked higher than existing program and the existing program is eliminated from further consideration. If the reverse is true, the existing program is rated higher and the new program is eliminated (Institute for Educational Development, 1969, p. 29).

Regardless of the technique used, both the cost-effectiveness tabular display technique and the analytical model technique relate costs and effectiveness so that the merits of the alternatives may be analyzed for the selection of the preferred alternative (Bryk, 1965, p. 4).



INPUTS

INSTRUCTIONAL OBJECTIVES
- NUMBER AND TYPES OF GRADUATES
- TYPES OF COURSES
- STUDENT PROFICIENCY
- SCHEDULE FOR PRODUCING GRADUATES

CHANGES IN INSTRUCTIONAL OBJECTIVES
- INCREASE IN NUMBER OF STUDENTS TO GRADUATE

RESOURCE AVAILABILITY
- INSTRUCTORS
- STUDENTS
- FACILITIES
- INSTRUCTIONAL MATERIALS
- EQUIPMENT
- COURSE CONTENT DEVELOPMENT
- SOFTWARE
- FUNDS
- TIME

CHANGES IN RESOURCES AVAILABILITY
- REDUCTION IN NUMBER OF INSTRUCTORS

TEST FOR FEASIBILITY (BASED ON A COMPARISON OF OBJECTIVES WITH RESOURCE REQUIREMENTS)

To Sheet No. 2

ELIMINATE INFEASIBLE ALTERNATIVES FROM FURTHER CONSIDERATION

Note: After Institute for Educational Development, 1969, p. 42

Figure 10. Analytical Model Example (Sheet 1 of 5)

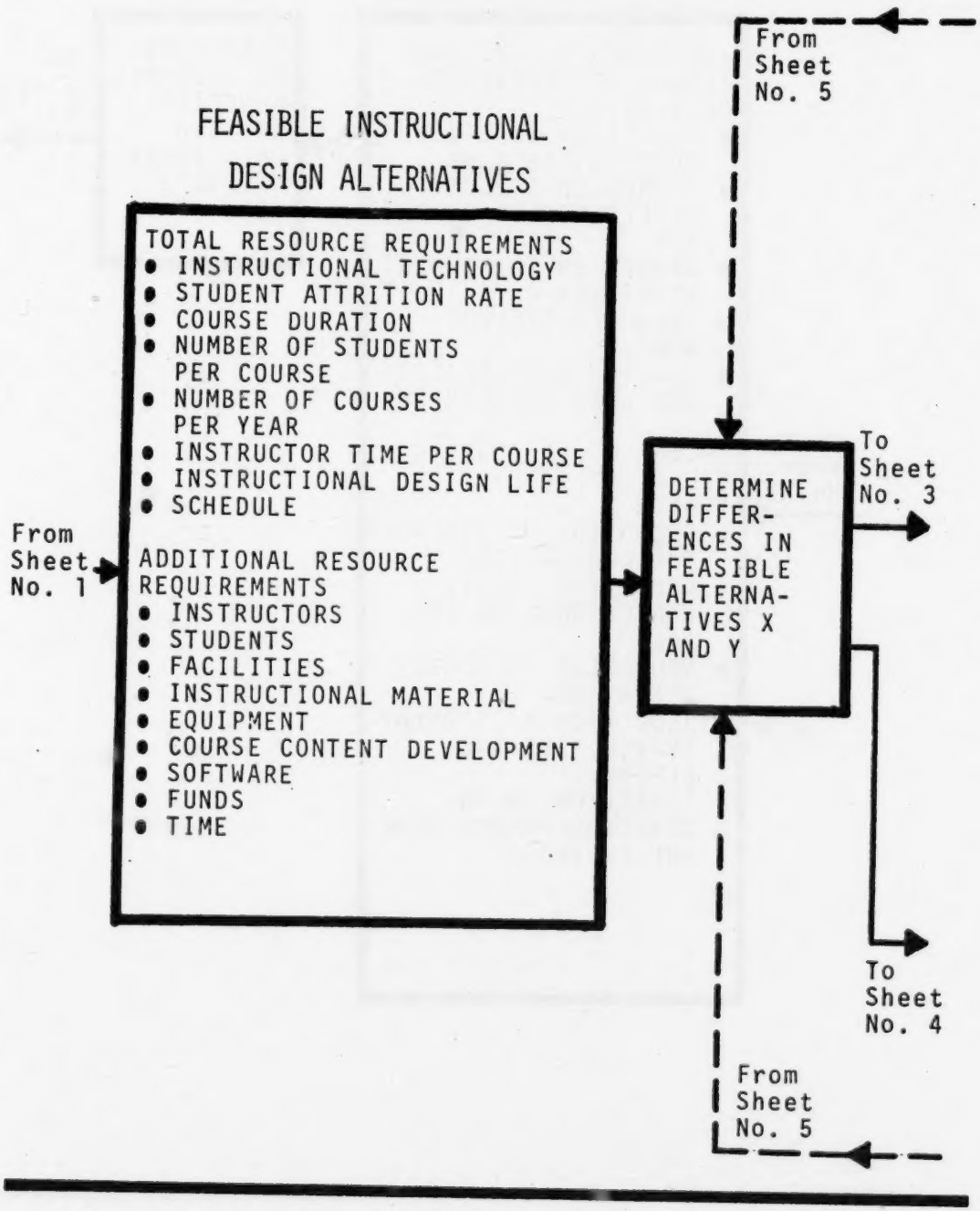


Figure 10. Analytical Model Example (Sheet 2 of 5)

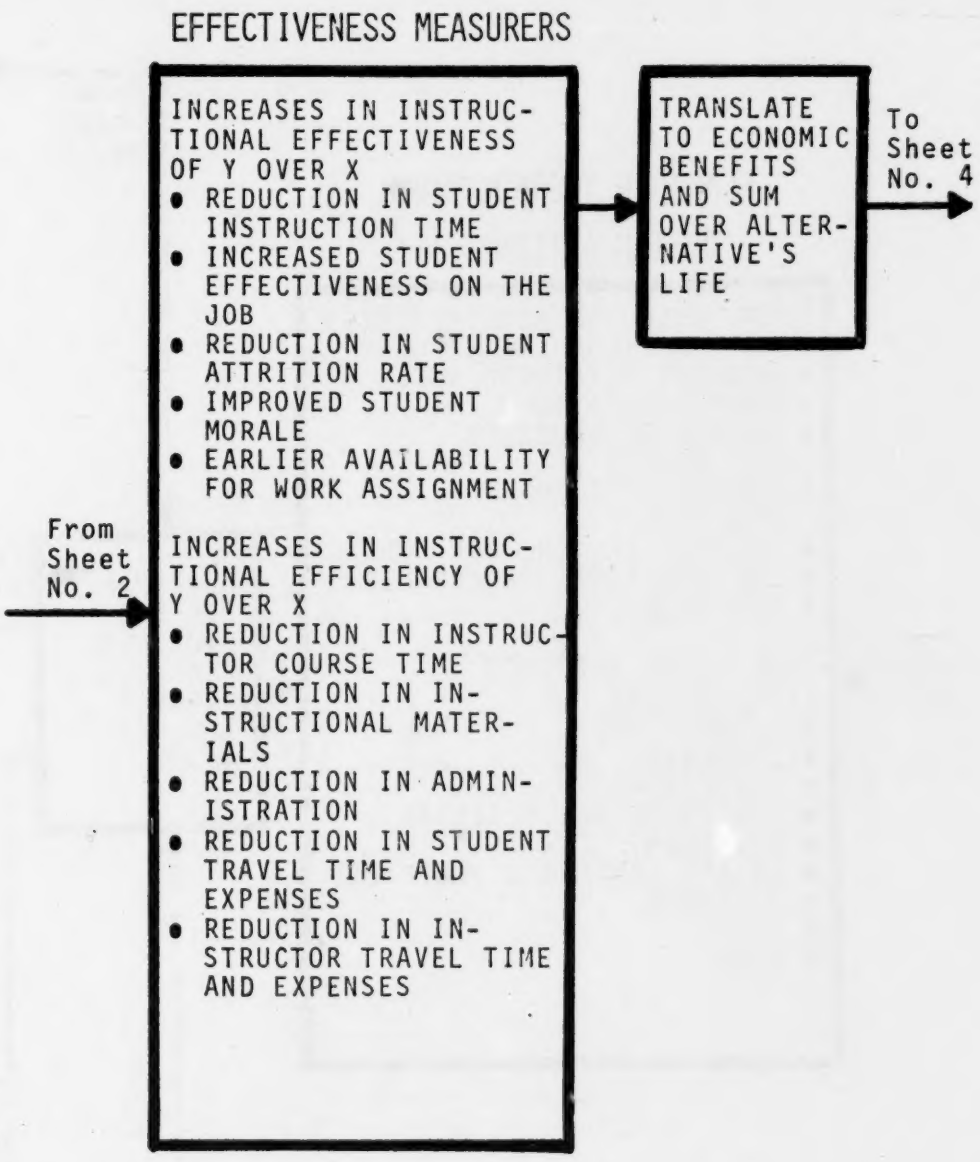

EFFECTIVENESS MEASURERS
INCREASES IN INSTRUCTIONAL EFFECTIVENESS OF Y OVER X
• REDUCTION IN STUDENT INSTRUCTION TIME
• INCREASED STUDENT EFFECTIVENESS ON THE JOB
• REDUCTION IN STUDENT ATTRITION RATE
• IMPROVED STUDENT MORALE
• EARLIER AVAILABILITY FOR WORK ASSIGNMENT
INCREASES IN INSTRUCTIONAL EFFICIENCY OF Y OVER X
• REDUCTION IN INSTRUCTOR COURSE TIME
• REDUCTION IN INSTRUCTIONAL MATERIALS
• REDUCTION IN ADMINISTRATION
• REDUCTION IN STUDENT TRAVEL TIME AND EXPENSES
• REDUCTION IN INSTRUCTOR TRAVEL TIME AND EXPENSES
From Sheet No. 2
TRANSLATE TO ECONOMIC BENEFITS AND SUM OVER ALTERNATIVE'S LIFE
To Sheet No. 4

Figure 10. Analytical Model Example (Sheet 3 of 5)

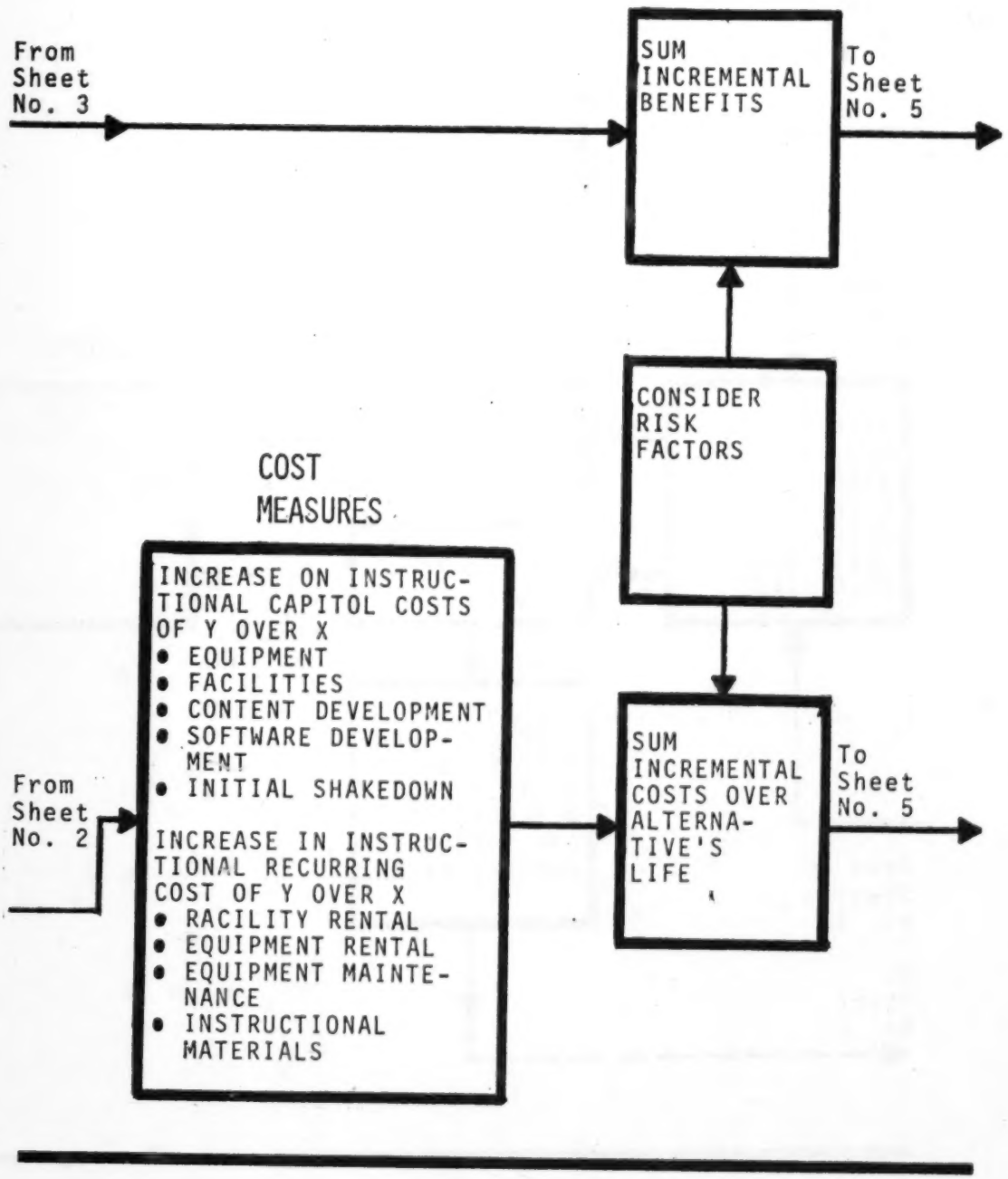


Figure 10. Analytical Model Example (Sheet 4 of 5)

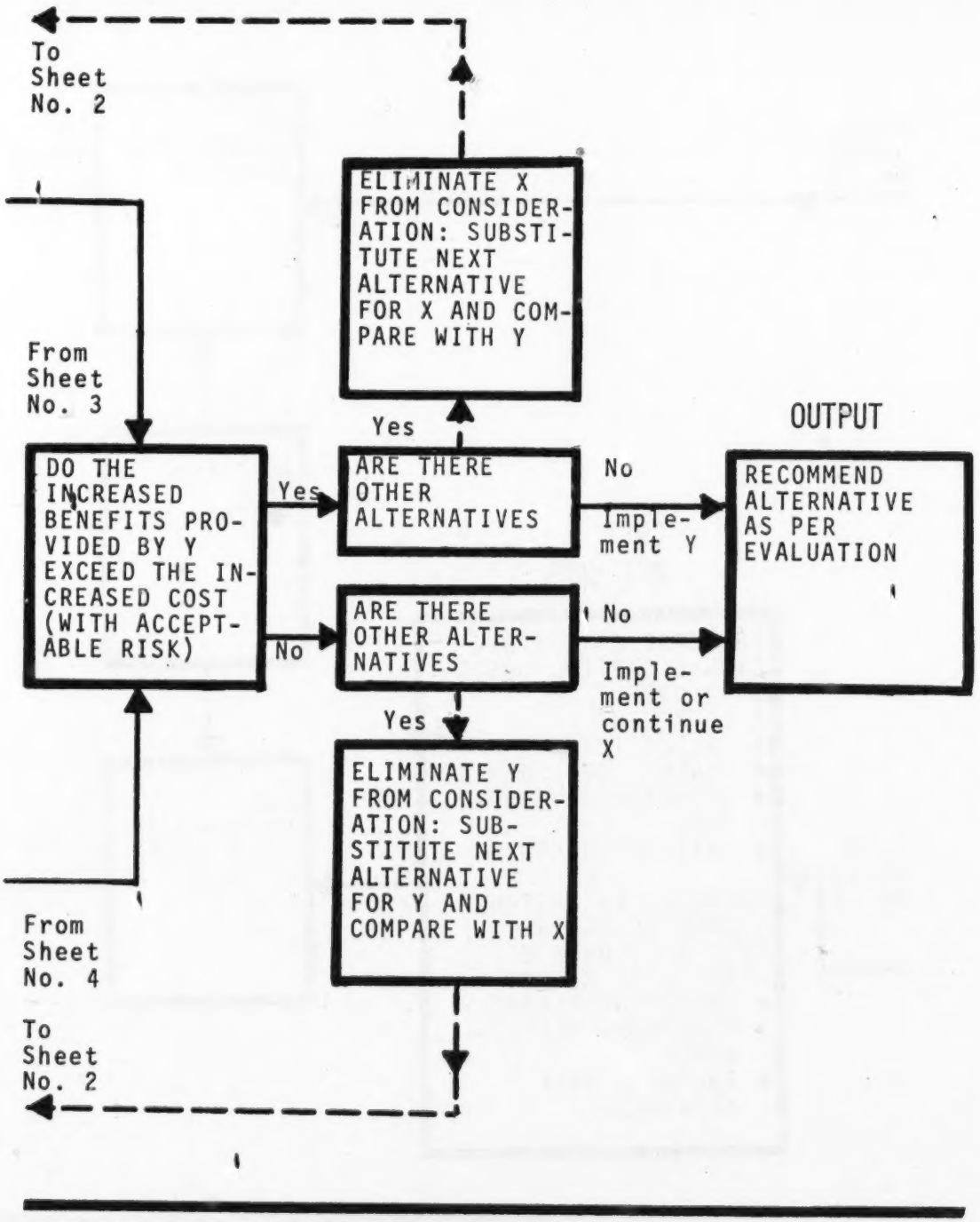

To Sheet No. 2
ELIMINATE X FROM CONSIDERATION: SUBSTITUTE NEXT ALTERNATIVE FOR X AND COMPARE WITH Y
From Sheet No. 3
Yes
OUTPUT
DO THE INCREASED BENEFITS PROVIDED BY Y EXCEED THE INCREASED COST (WITH ACCEPTABLE RISK)
Yes
ARE THERE OTHER ALTERNATIVES
No
Implement Y
RECOMMEND ALTERNATIVE AS PER EVALUATION
No
ARE THERE OTHER ALTERNATIVES
No
Implement or continue X
Yes
ELIMINATE Y FROM CONSIDERATION: SUBSTITUTE NEXT ALTERNATIVE FOR Y AND COMPARE WITH X
From Sheet No. 4
To Sheet No. 2

Figure 10. Analytical Model Example (Sheet 5 of 5)

Once the alternatives are arranged in order of their acceptability in relationship to the evaluation criteria, it is generally possible to eliminate the most obviously poorest competitors and focus attention on the top three or four. If the effectiveness and cost evaluation outcomes for the top alternative are consistently superior to the respective values of the other alternatives, then that alternative is the preferred selection. If the performance values for the top alternatives are virtually identical, and no significant difference in cost exists, the appropriate conclusion may be that there is no significant difference between the top candidates. In this case, the adoption of parallel study or development efforts of both top candidates may be indicated in order to identify the preferred alternative. This would mean that one alternative would be selected at a later date. If the costs of the competing alternatives differ significantly, and the evaluation ratings also vary significantly, the selection may need to be made on the basis of personal value judgments (Kazanowski, 1968, p. 135).

Step 10

Analyze uncertainty factors. All cost-effectiveness analysis studies include doubtful features that may not be satisfactorily specified or quantitatively resolved within the study itself (Brechner, 1967, p. 57). Important decision problems involve major elements of uncertainty. Consequently, a cost-effectiveness analysis of such problems must provide for the explicit treatment of uncertainty for consideration by the decision-maker.

Two main types of uncertainty may be distinguished: (1) uncertainty about the state of the world in the future, and (2) statistical uncertainty about the data on the present state of the alternative. State-of-the-future uncertainty stems from chance elements in the real world and would exist even if there were no ties of the state to the world of the future (Fisher, 1967, pp. 72-73). Statistical data uncertainty is most closely associated with cost-effectiveness analysis because, unfortunately, the choices between alternative candidates are seldom made on the basis of clear-cut data. Factors which add to the uncertainties include: (1) alternatives are frequently inadequate to fully attain the objectives, (2) measures of effectiveness may not actually measure the extent to which objectives are attained, (3) predictions from the cost-effectiveness model are apt to be full of uncertainties, and (4) other criteria which look almost as attractive as the criteria chosen may lead to a

different order of preference (Quade, 1969, p. 5). Three types of uncertainty analysis are most often used to treat statistical uncertainties. These are: (1) sensitivity analysis, (2) contingency analysis, and (3) a Fortiori analysis.

Sensitivity Analysis. In many instances the output of a cost-effectiveness analysis is very sensitive to the assumptions made. The conclusions reached may be unknowingly yet significantly biased by some apparently innocuous assumptions which are essential to the analysis (Kazanowski, 1968, p. 138). For example, suppose in a given analysis there are several uncertain key parameters. Instead of using "expected values" for these parameters, the analyst could test for the influence of these assumptions by substituting several values (i.e., high and low) in an attempt to see how sensitive the results (the ranking of the alternatives being considered) are to variations in these uncertain parameters (Fisher, 1967, p. 73). Another example would be an instance in which the alternatives are nearly equal in merit. Here, it would be desirable to attempt to estimate the cost-effectiveness that would be derived from the candidate alternatives if they were cancelled at three or four different major life-cycle schedule milestones. It is also desirable to perform this analysis even when one candidate alternative appears to be clearly superior with respect to both cost and effectiveness criteria. Such an analysis may point out the need for caution in making an otherwise unqualified endorsement of the alternative (Kazanowski, 1968, pp. 138-139).

Contingency Analysis. This type of analysis investigates how the ranking of the candidate alternatives maintains ranking when a relevant change in criteria for evaluating the alternatives is postulated, or a major change in the general environment is introduced. These techniques assess the degree to which results are contingent upon any <u>one</u> factor, or each of several factors.

A Fortiori Analysis. This type of analysis would be applicable when in a planning decision problem the generally accepted intuitive judgment strongly favors alternative X. The analyst feels, however, that X might be a poor choice and that alternative Y might actually be preferable. In performing an analysis of X versus Y, the analyst may choose deliberately to resolve the major uncertainties in favor of X and see how Y compares under these adverse conditions.

Although the above three types of uncertainty analysis may be useful in a direct sense, they may also contribute indirectly. For example, through sensitivity and contingency analysis the analyst may improve his understanding of critical uncertainties in a problem area. On the basis of this knowledge he might then be able to create a new alternative that would assume more protection against a wider range of uncertainties. This is often difficult to do but when it can be accomplished, it offers one of the best ways to compensate for uncertainty (Fisher, 1967, pp. 73-74).

Step 11

Document bases of previous steps and submit findings. The product of a cost-effectiveness analysis study, will in all probability be a report to the decision-maker. In support of this report a key element of systematic cost-effectiveness analysis is sufficient documentation of methods, assumptions, sources, etc., so that another analyst would achieve substantially the same results with the same material. Without such documented results, a cost-effectiveness analysis appeal for acceptance rests solely on faith in the authority and expertise of the analyst without critical examination of the way in which he arrived at the recommendations (Heymont, 1965, p. 20).

Particular emphasis should be placed on the adequacy of documenting the following:

- Specific goals/objectives to be attained.
- Essential requirements of those goals/objectives along with associated assumptions.
- Alternative capabilities and associated assumptions.
- Alternative costs and associated assumptions (learning curves, time, quantities, etc.).
- Alternative evaluation and associated assumptions (scenarios, criteria, etc.).
- Conclusions: The recommended alternative, the limitations, and the associated uncertainty factors.

The use of highly esoteric mathematics for documentation should be discouraged. With effort, imagination, and forethought, the analyst can usually suitably portray complex mathematical and functional relationships in simplified and perhaps graphic form.

No judicious decision-maker can be expected to endorse a conclusion or recommendation whose rationale and derivation he cannot fully understand. It is the responsibility of the analyst to present the documentation in an appropriate and understandable manner. To have a high probability of acceptance by the decision-maker all elements of the cost-effectiveness analysis must be documentated in such a manner that the entire process can be clearly followed (Kazanowski, 1968, pp. 139-140).

COST-EFFECTIVENESS ANALYSIS
DIFFERENCES AND CHARACTERISTICS OF METHODS

From the instructional cost-effectiveness analyst's point of view, the selection of a study category and an analytical process to be used is determined by requirements outside of the control of the analyst. These requirements are determined either by the requestor of the study or by the type of study itself. Only within the procedure of the cost-effectiveness analysis itself does the analyst have a choice in analytical technique. This standard procedure for cost-effectiveness analysis underlies the methods previously described. These methods contained certain functional elements with differing characteristics which should be considered in any standard step procedure used by the analysis. Latitude is acceptable in the manner and procedure of analytical steps for a certain amount of overlap and duplication are present in the steps. Figure 11 illustrates the function, differences, and characteristics of the various cost-effectiveness methods.

FUNCTION

The following functional elements are considered necessary in the performance of a cost-effectiveness analysis.

- Step 1. Review definition of general goals/objectives.
- Step 2. Review identification of parameters or requirements.
- Step 3. Review development of alternatives.
- Step 4. Establish cost and effectiveness evaluation criteria.
- Step 5. Determine cost of alternatives.
- Step 6. Determine capabilities or effectiveness of alternatives.
- Step 7. Select fixed-cost or fixed-effectiveness approach.
- Step 8. Create alternatives versus criterion array.

COST-EFFECTIVENESS ANALYSIS STANDARD PROCEDURE

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 1 REVIEW DEFINITION OF GENERAL GOALS/ OBJECTIVES		
STEP 2 REVIEW IDENTIFICATION OF PARAMETERS OR REQUIREMENTS		
STEP 3 REVIEW DEVELOPMENT OF ALTERNATIVES		
STEP 4 ESTABLISH COST AND EFFECTIVENESS EVALUATION CRITERIA	COST MEASURES • NON-TIME PHASED ANALYSIS • TIME-PHASED ANALYSIS	CHOICE DETERMINED BY CATEGORY OF STUDY
	EFFECTIVENESS MEASURES • PERFORMANCE IDENTIFIERS • STANDARDS • UNIQUE EDUCATIONAL	CHOICE DETERMINED BY GOALS/OBJECTIVES/REQUIREMENTS
STEP 5 DETERMINE COST OF ALTERNATIVES		

Note: After Pearson, 1972, p. 112

Figure 11. Cost-Effectiveness Analysis Functions, Differences, and Characteristics (Sheet 1 of 3)

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 6 DETERMINE CAPABILITIES OR EFFECTIVENESS OF ALTERNATIVES		
STEP 7 SELECT FIXED-COST OR FIXED-EFFECTIVENESS APPROACH		
STEP 8 CREATE ALTERNATIVES VERSUS CRITERION ARRAY	TABULAR DISPLAY TECHNIQUE	CHOICE DETERMINED BY EVALUATION CRITERIA; RECOMMENDED WHEN CRITERIA VARY WIDELY
	MODEL TECHNIQUE • OPERATIONAL EXERCISE • GAMING • SIMULATION	NOT RECOMMENDED FOR INSTRUCTIONAL COST-EFFECTIVENESS ANALYSIS BECAUSE OF COMPLEXITY
	• ANALYTICAL	RECOMMENDED FOR USE WHEN THE GOALS/OBJECTIVES/REQUIREMENTS CAN BE STATED IN TERMS SUCH THAT MATHEMATICAL AND GRAPHIC TECHNIQUES CAN BE USED

Figure 11. Cost-Effectiveness Analysis Functions, Differences, and Characteristics (Sheet 2 of 3)

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 9 ANALYZE MERITS OF ALTERNATIVES	TABULAR DISPLAY TECHNIQUE	CHOICE DETERMINED BY EVALUATION CRITERIA; RECOMMENDED WHEN CRITERIA VARY WIDELY
	MODEL TECHNIQUE • OPERATIONAL EXERCISE • GAMING • SIMULATION	NOT RECOMMENDED FOR INSTRUCTIONAL COST-EFFECTIVENESS ANALYSIS BECAUSE OF COMPLEXITY
	• ANALYTICAL	RECOMMENDED FOR USE WHEN THE GOALS/OBJECTIVES/REQUIREMENTS CAN BE STATED IN TERMS SUCH THAT MATHEMATICAL AND GRAPHIC TECHNIQUES CAN BE USED
STEP 10 ANALYZE UNCERTAINTY FACTORS	SENSITIVITY ANALYSIS	RECOMMENDED FOR USE WHEN SELECTION CONCLUSION MAY BE BASED ON ASSUMPTIONS
	CONTINGENCY ANALYSIS	RECOMMENDED FOR USE WHEN EVALUATION CRITERIA MAY BE UNCERTAIN
	FORTIORI ANALYSIS	RECOMMENDED FOR USE WHEN SELECTION MAY BE BASED ON INTUITIVE JUDGMENT
STEP 11 DOCUMENT BASIS OF PREVIOUS STEPS AND SUBMIT FINDINGS		

Figure 11. Cost-Effectiveness Analysis Functions, Differences, and Characteristics (Sheet 3 of 3)

- Step 9. Analyze merits of alternatives.
- Step 10. Analyze uncertainty factors.
- Step 11. Document basis of previous steps and submit findings.

DIFFERENCE

Differences occur in the performance of various cost-effectiveness analysis in several functional elements of the standard procedural steps. These differences are found and described in some detail in Step 4, Step 8, Step 9, and Step 10 of Figure 11.

CHARACTERISTIC

Characteristics of the differences in Step 4, Step 8, Step 9, and Step 10 of the functional elements of the standard procedure are also considered in Figure 11. It is noted, however, that the principle differences in cost-effectiveness analysis methods are in Step 8 (create alternative versus criterion array) and in Step 9 (analyze merits of alternatives). These two differences are actually the same; i.e., the choice of using the tabular display technique or the analytical model technique. This is the only methodological choice available to the cost-effectiveness analyst not determined by others, determined by the type of study itself, or influenced by outside conditions.

COST-EFFECTIVENESS ANALYSIS
SELECTION OF TECHNIQUES FACTORS

Only within certain functional elements of the standard step procedure is there a choice of analytical techniques that may be used. In general these are choices between the tabular display technique and the analytical model technique. The tabular display technique may be used for all applications, but the analytical model technique is recommended for use only when the alternative criteria do not vary greatly and when the goals/objectives/and requirements can be stated in terms that will adapt themselves to mathematical and graphic techniques.

Other advantages and disadvantages in the selection of either the tabular display technique or the analytical model technique should be considered in the selection of one of these techniques for instructional cost-effectiveness analysis. Figure 12 exhibits these considerations, which are as follows:

TABULAR DISPLAY TECHNIQUE

The advantages of this technique are: (1) ease of evaluation, (2) traceable data conditions, (3) low cost, (4) may be used for all categories of analysis as well as both cost and effectiveness evaluations, and (5) easily modified to meet new requirements.

The disadvantages of the tabular display are: (1) unrealistic to the real world, (2) does not have computer capability, if required, and (3) an easily understood graphic form must be created for presentation to the decision-maker.

ANALYTICAL MODEL TECHNIQUE

The advantages of this technique are: (1) computer capability, if required, but need not be computerized, (2) lowest cost for models and simulation, (3) speed in cost modeling and evaluation, and (4) as a by-product of the analytical model process, may have an easily understood graphic form for presentation to the decision-maker.

The disadvantages of the analytical model technique are: (1) data traceability is lost in the analytical process, (2) limited to analysis between similar alternatives, (3) not appropriate for effectiveness evaluation, and (4) inflexible to change.

CHOICE OF TECHNIQUE CONSIDERATIONS

TECHNIQUE	ADVANTAGE	DISADVANTAGE
TABULAR DISPLAY TECHNIQUE	A. EASE OF EVALUATION B. DATA CONDITIONS TRACEABLE C. LOW COST D. USED FOR ALL CATEGORIES OF ANALYSIS AS WELL AS BOTH COST AND EFFECTIVENESS EVALUATIONS E. EASILY MODIFIED TO MEET NEW REQUIREMENTS	A. UNREALISTIC B. COMPUTER CAPABILITY NOT AVAILABLE C. EASILY UNDERSTOOD GRAPHIC FORM FOR DECISION-MAKER MUST BE CREATED
ANALYTICAL MODEL TECHNIQUE	A. COMPUTER CAPABILITY, BUT NEED NOT BE COMPUTERIZED B. LOWEST COST FOR MODELS C. SPEED IN COST MODELING AND EVALUATION D. EASILY UNDERSTOOD GRAPHIC FORM FOR DECISION-MAKER AVAILABLE	A. LOSS OF DATA TRACEABILITY B. LIMITED TO ANALYSIS BETWEEN SIMILAR ALTERNATIVES C. NOT APPROPRIATE FOR EFFECTIVENESS EVALUATION D. INFLEXIBLE TO CHANGE

Note: After Pearson, 1972, p. 141

Figure 12. Cost-Effectiveness Analysis Selection of Techniques

COST-EFFECTIVENESS
APPLICATION TO INSTRUCTIONAL DEVELOPMENT

This monograph has provided for the instructional designer procedural steps to follow in the performance of instructional cost-effectiveness analysis. In addition, the procedural elements may be used as a checklist in the evaluation of existing instructional cost-effectiveness studies performed by others.

IMPLICATIONS

The direct implication of cost-effectiveness as a decision-assisting tool for instructional development are that: (1) the performance of cost-effectiveness analysis may be formal or informal, (2) the analysis time involved may be 30 minutes or a week, (3) all of the procedural elements may or may not be considered; and (4) the degree of detail explored may or may not be great. Instructional cost-effectiveness analysis is best performed as a service by someone other than the final decision-maker. This person may be an instructional designer or as a highly specialized service to the designer. The final decision-maker served most often might be: (1) an academic dean or department head, (2) a training manager or supervisor in industry or government, or (3) a public school system superintendent or instructional program director. At the present state of development and acceptance, cost-effectiveness analysis seems most applicable to instructional development in what might be called "adult or continuing education." The compensatory, vocational, and business instructional programs in school systems could benefit most immediately from a systems/cost analysis. It is further thought that merit pay, performance contracting, and accountability in instruction could provide the impetus to bring cost-effectiveness into public school systems.

PROBLEM AREAS

It seems worthwhile to note certain general areas of unique problems associated with the use of cost-effectiveness analysis in the selection of alternatives during instructional design and development. These are areas in which problems may be overcome by further experience and information-sharing.

- Software (Manual, semiautomatic, and automatic) must be developed which will allow updating of

the cost and effectiveness model consistent with experience, and improvement in the cost-effectiveness model itself.

- More experience is needed in the design of cost-effectiveness modeling as well as cost-effectiveness user training at the local application level (Filep, 1970).

- Current data is inadequate for both cost and effectiveness modeling due to the lack of historical records (Institute for Educational Development, 1969, p. 49). Records on either budget or performance estimates versus compliance are not being maintained. Perhaps what is needed is the design of some reporting instrument in a format for instructional cost and effectiveness data extraction (Filep, 1970).

- Additional research is needed before cost-effectiveness analysis can be used with understanding.

RECOMMENDATIONS

The following recommendations are offered to assist further research efforts of others in the area of instructional cost-effectiveness analysis.

Changes in cost-effectiveness nomenclature and terminology that have the same prior meaning should be noted. Government activities represent the largest concentration of potential clients for operations research, systems/cost analysis, and the like. Because of changes in political administration, these activities will be in frequent flux as to what today's terminology is "in." As a consequence, today's trend seems to be away from the terminology so popular during the 1960's. It is suggested that perhaps a more meaningful terminology could be designated for instructional design purposes.

Instructional cost-effectiveness analysis has not received either the credit or publicity earned. No reports from public school systems using cost-effectiveness analysis were found. If cost-effectiveness analysis is indeed used to the extent reported in the study (48 percent), it would seem that more should be published on the performance and result of the cost-effectiveness method itself. It is suggested that more instructional designers with cost-effectiveness expertise disseminate their experiences.

More information is needed on measures of performance regarding both cost and effectiveness. Measures of the consequences of failure (lack of effectiveness) should be also considered. It would be desirable if unique measures of performance could be developed for instructional design that were general enough for differing applications. It is recommended that some sort of "clearing house" or responsible organization acquire, maintain, and disseminate historical performance measurement information on instructional cost and effectiveness.

An analytical model for instructional cost-effectiveness that could be easily modified for differing applications is needed. This model should be designed with computer capability and available operational instructions. It is recommended that such a computerized analytical model be developed, and be made available to clients on a commercial basis.

Research on the direct application of instructional cost-effectiveness is almost nonexistent. It is suggested that several aspects of this study are applicable for further in-depth study, with an emphasis on real-world application.

SUMMARY

Much has been reported on the advantages of cost-effectiveness analysis as a decision-assisting tool for instructional development. Little, however, has been reported regarding the actual performance of the analysis itself. Although a variety of cost-effectiveness analysis methods exists, it was theorized that one method might be more applicable to the unique requirements of instructional design and development. The purpose of the monograph, therefore, is to identify and analyze the various cost-effectiveness analysis methods so that the most appropriate method could be selected as a decision-assisting tool.

What appeared to be a large variety of cost-effectiveness analysis methods is due to choices (1) in the "level" of analysis, (2) in the process of analysis, and (3) in the analytical methods employed. The choices of "level" and process of analysis are usually outside of the control of the cost-effectiveness analyst. This is because both "level" and process of analysis are determined by the requestor or by the nature of the study itself. Within the analytical methods, however, the procedures used in the cost-effectiveness studies are described in terms of 11 procedural steps. Within these procedural steps only a limited number of pathways or alternative techniques are options available to the analyst. These options were determined by the characteristics of two analytical techniques approaches. These two approaches were the tabular display technique and the model technique. The tabular display technique was found recommended for all cost-effectiveness applications but the model technique was limited for use when the alternative criteria did not vary greatly, and when the goals/objectives/requirements could be stated in terms that would adapt to mathematical and graphic techniques. In addition, the tabular display technique is recommended as a decision-assisting tool for instructional design and development because of the characteristics of easily understood results and traceable data conditions.

In the selection of alternative instructional design, the following major considerations are involved in performing cost-effectiveness analysis:

- Proper structuring of the problem. The analysis addresses itself to the goals/objectives definition as well as requirement identification.

- An appropriate procedure and systematic analytical framework must be employed in making comparisons. Measures of cost and effectiveness must be identified and criteria established so that subsequent and capabilities data may be appropriately modeled.

- Model construction (either formal or informal) is usually necessary in the analytical process. The main purpose of the model is to develop relationships among objectives, the relevant alternatives available for attaining the objectives, the estimated cost of the alternatives, and the estimated performance capabilities for each alternative.

- Because the model is only an abstract representation of reality, it is desirable to perform validity checking of the analytical procedure; e.g., how well can the model describe known facts and situations?

- Uncertainty factors regarding the analysis must be indentified.

Once accomplished the instructional cost-effectiveness analysis and the resulting alternative recommendation can be a significant addition to decision-assisting tools.

APPENDIX

DEFINITION OF TERMS USED

Cost. Unit of resource that is the limiting constraint. Dollars are used in most cases but other resources, such as manpower, materials, and facilities will also be considered as measures of cost (Hatry, 1969, p. 44).

Cost-benefit analysis. A problem solving approach which requires the definition of objectives, and identification of the alternative that: (1) yields the greatest benefit for a given cost; or what amounts to the same thing, (2) that yields a required amount of benefits for the least cost. The term usually applies to situations in which the alternative outputs can be quantified in dollars. A chief characteristic is that the aim is to calculate the present value of benefits and costs, subject to specified constraints.

Cost-effectiveness analysis. A problem solving approach which requires the definition of objectives, identification of alternative ways of achieving the objective, and identification of the alternative that: (1) yields the greatest effectiveness for any given cost, or what amounts to the same thing, (2) that yields a required degree of effectiveness for the least cost. The term is usually used in applications in which the alternative outputs cannot be easily quantified in dollars (McGivney and Nelson, 1969, p. 105).

Cost-utility analysis. Same as cost-effectiveness analysis (Anshen, 1967, p. 3). Numerous terms currently convey the same general meaning (i.e., systems analysis, operations analysis, cost-effectiveness analysis, and operations research); however, they have varying connotations to different people (Fisher, 1967, p. 66). Because of such confusion in terminology and meaning, cost-effectiveness will be the term used to reflect the level of intent of the study.

Discounted cost. An analytical technique that accounts for the fact that money to be paid in the future yields investment return until the point in time when it is actually spent; consequently, present money spent is worth less than future money spent (Seiler, 1969, p. 17).

Effective. The accomplishment of the recognized objectives (Beynon, 1968, p. 84).

Initial cost. Investment in goods and services required to establish and operate a system. These goods have a useful value of longer than a year; thus the costs are not repeated every year (Esseff, 1970).

Life cycle costs. Combined initial costs and operational costs for the estimated useful life of the system (Esseff, 1970).

Model. Relations used to portray real or expected conditions, actions, or effects in order to predict the outcome of actions (Heymont, 1965, p. 56).

Objective. A statement that describes in observable and measurable terms the expected output performance of the product of the system (Banathy, 1968, p. 89).

Planning, programming, and budgeting system (PPBS). Cost-benefit analysis on a large scale (Commission on Instructional Technology, 1970, p. 90). A conceptual approach to decision-making which emphasizes outputs, program activities, and accomplishments. Long-range planning, analytic evaluative tools, and economic rationality are basic ingredients (Hartley, 1968, p. 258).

System. An integrated relationship of people, equipment, and methods appropriately organized to accomplish defined tasks (Heymont, 1965, p. 59).

Systems analysis (systems approach). Self-correcting and logical methodology of decision-making to be used for the design development of manmade entities. Strategies of this methodology include: (1) the formulation of performance objective, (2) the analysis of functions and components, and (3) implementation (Banathy, 1968, p. 91).

Time-phased cost. The presentation of costs by the time period in which the costs occur rather than a total cost figure (Heymont, 1965, p. 60).

Trade-off. The weighing of alternative means to be employed for the accomplishment of required functions (Banathy, 1968, p. 91). Cost-effectiveness analysis represents one aspect of trade-off analysis.

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